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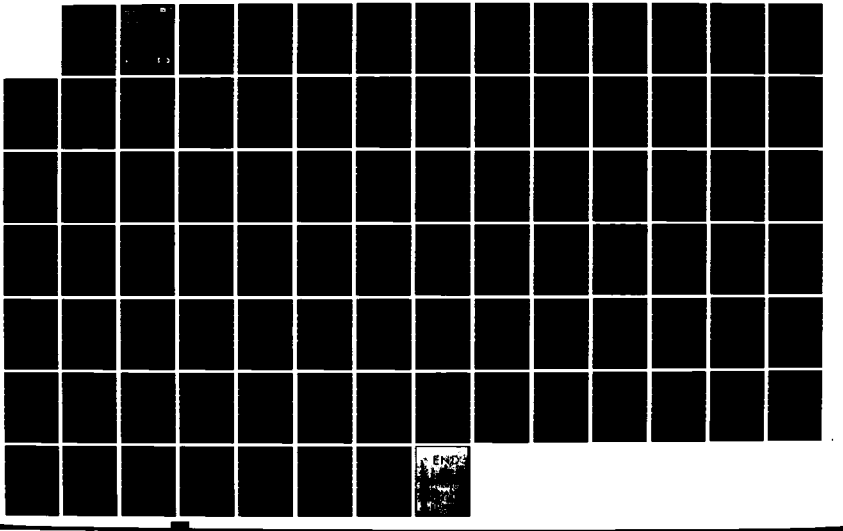

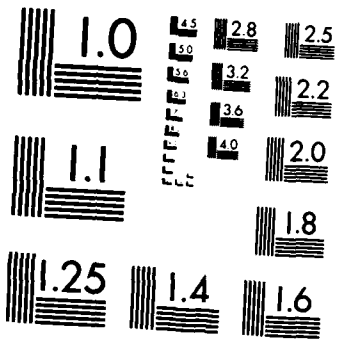

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Special Report 83-9

April 1983

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

Corps of Engineers land treatment of wastewater research program

An annotated bibliography

L.V. Parker, P.A. Berggren, I.K. Iskandar, D. Irwin, C. McDade and M. Hardenberg

Prepared for
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This bibliography contains publications of research funded in whole or in part by the Corps of Engineers Land Treatment Research Program, conducted from January 1972 to May 1982. The program was officially complete in October 1980. Six types of publications are included: 1) publications in open literature (which may include papers in journals, chapters in books and books), 2) technical reports, 3) engineer technical letters, 4) draft translations (mainly from Russian), 5) theses and dissertations (M.S., Ph.D.), and 6) presentations at scientific conferences.

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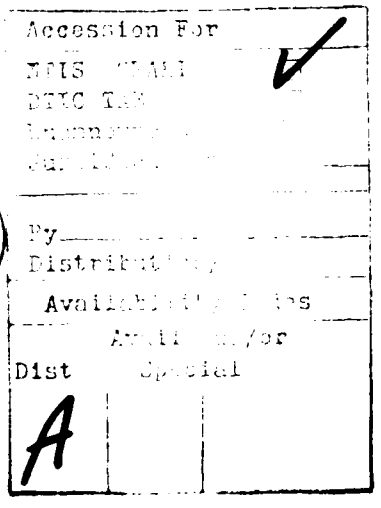
PREFACE

This report was prepared by L.V. Parker, Microbiologist, Earth Sciences Branch, Research Division; P.A. Berggren, Computer Technician, Engineering and Measurement Services Branch, Technical Services Division; Dr. I.K. Iskandar, Research Chemist, Earth Sciences Branch, Research Division; D. Irwin and C. McDade former Physical Science Technicians, Earth Sciences Branch, Research Division; and M. Hardenberg, Technical Publications Editor, Technical Information Branch, Technical Services Division, U.S. Army Cold Regions Research and Engineering Laboratory. Financial support for the study was provided under Work Unit CWIS 31732, Land Treatment Management and Operation.

The authors acknowledge the generous assistance given by many individuals at CRREL and elsewhere by providing copies of their publications; special thanks to E. Rose for her assistance with the index and to T. Jenkins for his assistance. All publications in this bibliography were the result of research funded in whole or in part by the Corps of Engineers Land Treatment Research Program initiated in 1972.



CONTENTS

ABBREVIATIONS

BOD	Biological Oxygen Demand
CEC	Cation Exchange Capacity
FA	Fluorescent Antibody Technique for counting micro-organisms
GC-MS	Gas Chromatograph - Mass Spectrophotometer Analysis
M-FC	Membrane Fecal Coliform Procedure
MPN	Most Probable Number Technique for counting micro-organisms
SS	Suspended Solids
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TSS	Total Suspended Solids
C	Carbon
Ca	Calcium
Cd	Cadmium
Cl	Chloride
Cr	Chromium
Cu	Copper
Fe	Iron
Hg	Mercury
K	Potassium
Mg	Magnesium
Mn	Manganese
N	Nitrogen
Na	Sodium
NH_4^+	Ammonium
Ni	Nickle
N_2O	Nitrous Oxide
NO_2^-	Nitrite
NO_3^-	Nitrate
P	Phosphorus

Pb	Lead
PO_4^{2-}	Phosphate
Zn	Zinc
CAPDET	Computer Assisted Procedure for the Design and Evaluation of Wastewater Treatment Systems
COE	U.S. Army Corps of Engineers
CRREL	U.S. Army Cold Regions Research and Engineering Laboratory
CRREL TL	CRREL Translation
EPA	U.S. Environmental Protection Agency
NTIS	National Technical Information Service
SCS	Soil Conservation Service
USAEWES	U.S. Army Engineer Waterways Experiment Station
USDA	U.S. Department of Agriculture

AVAILABILITY

Open Literature: available from public libraries, the publisher, or from CRREL.

Technical Reports: available from NTIS or from CRREL.

Theses: available from University Press, Ann Arbor, Michigan, or from author.

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INTRODUCTION

In 1971 the U.S. Army Corps of Engineers conducted five comprehensive regional studies of wastewater management. These studies evaluated sites in San Francisco, California; Chicago, Illinois; Detroit, Michigan; Cleveland, Ohio; and the Merrimack River Basin in New England. Each study considered the overall feasibility of regional wastewater management and suggested alternative methods for achieving the treatment goals. In all plans, land treatment of wastewater was identified as a viable method for waste treatment and disposal.

In 1971 the technology for optimizing design and operation of cost-effective and environmentally safe land treatment systems was not available. In existing systems in the United States and other countries, the use of land for wastewater treatment was a trial-and-error practice because sufficient research had not yet been conducted, and in some instances the process was actually land disposal and not waste treatment. Land disposal of wastes has been practiced for thousands of years, and, as the name implies, it is the practice of discarding wastes on the land with little or no concern for their impact on the environment, particularly groundwater. Land treatment, on the other hand, is a relatively new concept. It is the practice of using the soil and its cover crops to treat wastewater, with concern for the impact on the receiving environment. Because of the lack of information on the proper design of land treatment facilities and because military facilities and the Corps of Engineers urban studies projects needed to evaluate and use such techniques, the Corps of Engineers land treatment research and development program was started in 1972.

The research program included long-term field experiments at different locations in the United States to establish design criteria, laboratory research to solve specific problems, and evaluation of existing land treatment and land disposal systems to document long-term effects.

Much of the research on slow rate and overland flow systems, the evaluation of existing facilities, and the establishment of criteria for design and operation of land treatment systems in cold climates was con-

ducted by CRREL in Hanover, New Hampshire. At Utica, Mississippi, the U.S. Army Engineer Waterways Experiment Station (USAEWES) conducted extensive research on overland flow treatment. At Apple Valley, Minnesota, the Corps of Engineers provided funds through CRREL to the U.S. Department of Agriculture for joint field studies on crop management for land treatment. At Pack Forest near Seattle, Washington, CRREL funded and helped to conduct a research program with the University of Washington on the use of forest systems to renovate wastewater. The Corps of Engineers also sponsored investigations of public health aspects of land treatment conducted by the U.S. Army Medical Bioengineering Research and Development Laboratory (USAMBRDL). Field studies on potential contamination by bacteria and viruses were conducted at Deer Creek, Ohio; Fort Devens, Massachusetts; and Hanover, New Hampshire. Many existing facilities for land disposal and treatment were visited and evaluated by the CRREL technical staff. Some of these systems, such as the one in Calumet, Michigan, have been in operation for more than 80 years.

This bibliography compiles published research results funded entirely or partially by the Corps of Engineers Land Treatment Research Program from 1972 through 1982. The cost of the program during this period was $8.4 million. The bibliography will be updated as needed.

Open Literature

Latterell, J.J., R.H. Dowdy, C.E. Clapp, W.E. Larson and D.R. Linden (1982) Distribution of phosphorus in soils irrigated with municipal wastewater effluent: A 5-year study. Journal of Environmental Quality, vol. 11, p. 124-128.

The specific objectives of this study are to determine the distribution of various P forms in soil irrigated 5 years with municipal wastewater and to measure the P-adsorption power of the soil following 5 years of P loading.

Martel, C.J. and C.R. Lee (1982) Overland flow: An alternative for wastewater treatment. The Military Engineer, vol. 74, p. 181-184.

This paper is intended to acquaint the military engineers who are unfamiliar with it with the overland flow technology. The research involved in developing the design criteria is discussed. The general construction characteristics and the necessary operation and maintenance procedures are also discussed.

Palazzo, A.J., T.F. Jenkins and C.J. Martel (1982) Vegetation selection and management for overland flow systems. In Land Treatment of Municipal Wastewater (F.M. D'itri, Ed.). Ann Arbor, Michigan: Ann Arbor Science Publishers Inc., p. 135-154.

This study has three objectives. The first is to determine which species of forage grasses should be used in overland flow systems, based on their speed of establishment and long-term persistance. The second is to obtain data on nutrient uptake by grasses in overland flow systems to be used to develop design criteria for nutrient removal. The final object is to determine forage grass yields and quality.

Schaub, S.A., H.T. Bausum and G.W. Taylor (1982) Fate of virus in wastewater applied to slow-infiltration land treatment systems. Applied and Environmental Microbiology, vol. 44, p. 383-394.

The removal of seeded coliphage f2 and indigenous enteroviruses from primary and secondary wastewaters applied by spray irrigation to sandy loam and silt loam soils in field test cells is examined. Sterilized soil core segments from different depths are studied to determine their virus adsorption capabilities when suspended in wastewater, test cell percolate water or distilled water containing divalent cations.

Technical Reports

Berggren, P.A. and I.K. Iskandar (1982) A users index to CRREL land treatment computer programs and data files. CRREL Special Report 82-26.

A users index is presented as a directory for the computer programs and data files developed at CRREL on land treatment. Two computers were used, one located at CRREL and the other at the Dartmouth Time Sharing System (DTSS), Dartmouth College, Hanover, New Hampshire. The objectives of this directory are to allow users to locate and use or request copies of desired programs or data files, to maintain a permanent record of programs and data files developed under the land treatment program, and to assist in technology transfer.

Bouzoun, J.R., D.W. Meals and E.A. Cassell (1982) A case study of land treatment in a cold climate: West Dover, Vermont. CRREL Report 82-44.

A slow rate land treatment system that operates throughout the year in a cold climate is described. Information on the geology, soils, vegetation, wildlife and the climate at the site is also presented. Winter operational problems such as ice formation on the elevated spray laterals, and freezing and plugging of the spray nozzles are discussed, as are their solutions. The results of a 1-year study to characterize the seasonal performance of the system, to develop N and P budgets for the system, to monitor specific hydrologic events on the spray field, to monitor shallow groundwater quality, to monitor the groundwater quality in off-site wells, and to monitor the water quality of two rivers that border the site are presented. Recommendations for the design and operation of other slow rate land treatment systems to be constructed in cold climates are included.

Iskandar, I.K. (1982) Overview of models used in land treatment of wastewater. CRREL Special Report 82-1.

This report summarizes the state-of-the-art of the modeling of wastewater renovation by land treatment. The models discussed are classified based on their use for planning, site selection and cost analysis, and for predicting 1) water and salt transport in soils, 2) N transport and transformations, 3) P transport and transformations, 4) virus movement in soils, and 5) toxic metal and trace organic movement in soils. This report compares the different models as to their purpose, input and output data, and status of validation. In addition, the report includes a section on research needs for modeling land treatment of wastewater.

Martel, C.J., T.F. Jenkins, C.J. Diener and P.L. Butler (1982) Development of a rational design procedure for overland flow systems. CRREL Report 82-2.

This report describes the development of a new design procedure for overland flow systems that is based on hydraulic detention time. A 2-year study was conducted on a full-scale overland flow site to obtain performance data in relation to detention time. Kinetic relationships are developed for removal of BOD, total SS, NH_4^+ and total P. Also, an empirical relationship is developed to predict hydraulic detention time as a function of application rate, terrace length and slope. These relationships are validated using published data from other systems. An example of how to use the new procedure and a comparison with the conventional design approach is included.

McKim, H.L., W.E. Sopper, D. Cole, W. Nutter, D. Urie, P. Schiess, S.N. Kerr and H. Farquhar (1982) Wastewater applications in forest ecosystems. CRREL Report 82-19.

This report summarizes the current state of knowledge concerning the application of municipal wastewater in forest ecosystems to assist in the design of such systems. This report supplements the Process Design Manual for Land Treatment of Municipal Wastewater.

Palazzo, A.J. (1982) Plant growth and management for wastewater treatment in overland flow systems. CRREL Special Report 82-5.

Domestic wastewater is applied over a 4-year period at various rates to three overland flow test slopes to study forage grass growth and nutrient removal. Plant yields, composition and uptake of nutrients are determined.

Ryden, J.C., J.K. Syers and I.K. Iskandar 1982. Evaluation of a simple model for predicting phosphorus removal by soils during land treatment of wastewater. CRREL Special Report 82-14.

This report evaluates a simple P balance model to predict site longevity with respect to P removal during land treatment. The model is based on measured inputs and outputs of P and on an estimate of the P storage capacity of the soil profile. Sorption of P by three soils used in land treatment is compared to the P sorption model.

Engineer technical letters

ETL 1110-2-525 (in prep.) Slow infiltration land treatment design criteria for plant uptake of nutrients.

This ETL presents guidance and recommendations for design and management of slow infiltration land treatment systems. This information is primarily related to forage grass growth and uptake of nutrients during the growing season.

ETL 1110-2-526 (1982) Crop management for overland flow wastewater treatment systems. 16 July.

Information and guidance for management of forage crops or vegetative cover on overland flow systems is presented in this ETL. Crop management aspects included in this study are 1) winter ryegrass overseeding, 2) frequency of harvesting, 3) intermittent and continuous wastewater application, 4) weed control and 5) insect control. These aspects are discussed in relation to runoff water quality, crop yield, crop nutrient, heavy metal uptake and maintenance of the grass cover.

ETL 1110-2-529 (1982) Wastewater application in forest ecosystems.

See CRREL Report 82-19 by McKim et al. under 1982 Technical reports.

1981 ENTRIES

Publications in open literature

Bosatta, E., I.K. Iskandar, N.G. Juma, G. Kruh, J.O. Reuss, K.K. Tanji and J.A. van Veen (1981) Status report on modeling of processes: Soil microbiology. In Simulation of Nitrogen Behavior in Soil Plant Systems (M.J. Frissel and J.A. van Veen, Eds.). Wageningen, the Netherlands: Pudoc, Centre of Agricultural Publishing and Documentation, p. 38-44.

The N transformations of interest to this workshop are nitrification, denitrification, mineralization-immobilization and biological N_2-fixation. Each of the above microbially-mediated reactions are examined relative to modeling approaches, to appraisal of mathematical modeling and validation, and to the effect of environmental and soil factors.

Chen, R.L. and W.H. Patrick, Jr. (1981) Efficiency of nitrogen removal in a simulated overland flow wastewater treatment system. Journal of Environmental Quality, vol. 10, p. 98-103.

In a simulated overland flow system, vertical measurements of redox potential indicate the presence of both oxidized and reduced zones that provided favorable conditions for simultaneous nitrification-denitrification reactions. Addition of C sources can substantially reduce the redox potential and enhance the rate of NO_3^- reduction. N transformation rates are examined by the use of labeled ^{15}N under controlled laboratory conditions.

Greene, S.M., M. Alexander and D.C. Leggett (1981) Formation of N-Nitrosodimethylamine during treatment of municipal wastewater by simulated land application. Journal of Environmental Quality, vol. 10, p. 416-421.

This study establishes the potential for nitrosamine formation under conditions resembling land treatment. Dimethylnitrosamine (DMNA) is selected for investigation because of its high toxicity and the ubiquity of its precursor, dimethylamine (DMA). The extent of DMNA formation and the behavior of its precursors are examined in soils incubated with sewage and in effluent from soil columns percolated with sewage.

Iskandar, I.K. (Ed.) (1981) Modeling Wastewater Revovation - Land Treatment. New York: John Wiley and Sons.

This book is written by a multidisciplinary group of scientists and engineers to fill a need for information on mathematical modeling of land treatment of liquid waste. Both research personnel and decision makers should find it useful in planning, designing and managing modern land treatment systems.

Iskandar, I.K. (1981) Introduction. Chap. 1. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 3-19.

This chapter gives general information on land treatment, characteristics of wastewater, mechanisms of wastewater renovation by land treatment, health aspects of land treatment and the need for mathematical models in land treatment plans, design, management and operation.

Iskandar, I.K. and H.M. Selim (1981) Validation of a model for predicting nitrogen behavior in slow infiltration systems. Chap. 18. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 508-533.

This chapter presents data for N model validation. The data come from a lysimeter study using two different soils and ^{15}N as a tracer. The N concentration in soil solution at different soil depths and in the leachate, plant uptake of N, and root distribution are monitored. Water flow, and N transport and transformation submodels are discussed.

Iskandar, I.K. and H.M. Selim (1981) Modeling nitrogen transport and transformations in soils: 2. Validation. Soil Science, vol. 131, p. 301-312.

This paper is a condensed version of chapter 18 by Iskandar and Selim (1981) in Modeling Wastewater Renovation - Land Treatment.

Iskandar, I.K., K.K. Tanji, D.R. Nielsen and D.R. Keeney (1981) Concluding remarks and research needs. Sec. 6. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 767-772.

This chapter makes concluding remarks and summarizes the research needs in modeling wastewater renovation.

Keeney, D.R. (1981) Soil nitrogen chemistry and biochemistry. Chap. 10. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 259-276.

This chapter presents general background on soil N chemistry and biochemistry as related to land treatment, with specific reference to mineralization-immobilization, nitrification, denitrification and crop removal. Critical review of N transformations in slow and rapid infiltration systems and overland flow systems is presented. Research needs are also discussed.

Leggett, D.C. and I.K. Iskandar (1981) Evaluation of a nitrification model. Chap. 12. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 313-358.

This chapter reviews the literature on modeling nitrification in soils and presents a model based on Michaelis-Menten kinetics. The effects on nitrification of soil pH, temperature and dissolved oxygen content are discussed. Model validation using laboratory data is also included.

Linden, D.R., C.E. Clapp and J.R. Gilley (1981) Effects of municipal wastewater effluent irrigation scheduling on nitrogen renovation, reed canarygrass production and soil water conditions. Journal of Environmental Quality, vol. 10, p. 507-510.

A 2-year field experiment is conducted to test the performance of reed canarygrass and the removal of N from wastewater under varying irrigation schedules.

Lund, L.J., A.L. Page, C.O. Nelson and R.A. Elliott (1981) Nitrogen balances for an effluent irrigation area. Journal of Environmental Quality, vol. 10, p. 349-352.

An 8.5-ha pasture irrigated with secondary sewage effluent is studied to determine the fate of N applied in the effluent. Soils of the Corralitos Series (Typic Xeropsamment) in nine plots were sampled twice to evaluate the variations in the field water contents and NO_3^--N and Cl^- concentrations in the unsaturated zone below the root zone. Crop removal, leaching and gaseous losses were evaluated for their role in N removal.

Mansell, R.S. and H.M. Selim (1981) Mathematical models for predicting reactions and transport of phosphorus applied to soils. Chap. 21. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 600-646.

This chapter reviews existing mathematical models for P transport and transformations in soils. Mathematical models that assume chemical equilibrium for reactions of P applied to soil, those that assume non-equilibrium, and those that assume a reversible P removal from solution to occur simultaneously by equilibrium and nonequilibrium reactions are discussed. Also discussed are mechanistic multiphase models for reactions and transport of P applied to soils and transport models for preferential movements of water and P through soil channels.

Mehran, M., K.K. Tanji and I.K. Iskandar (1981) Compartmental modeling for prediction of nitrate leaching losses. Chap. 16. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 444-477.

This chapter presents a simple N model for land treatment. This model consists of two submodels: a water-flow submodel and an N-flow submodel. The underlying principles of compartmental modeling are discussed. The model was evaluated with field data from Davis, California, and Hanover, New Hampshire.

Nakano, Y., R.L. Chen and W.H. Patrick Jr. (1981) Nitrogen transport and transformation in overland flow land treatment. Chap. 19. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 534-568.

This chapter presents a mechanistic N model for overland flow. Water movement and N transport and transformation are discussed. The model is validated with data from a laboratory scale model using ^{15}N as a tracer.

Palazzo, A.J. (1981) Seasonal growth and accumulation of nitrogen, phosphorus, and potassium by orchardgrass irrigated with municipal wastewater. Journal of Environmental Quality, vol. 10, p. 64-68.

This 2-year field study determines the seasonal growth and nutrient accumulation of a forage grass receiving 7.5 cm/week of domestic primary-treated wastewater. An established sward of Pennlate orchardgrass is managed on an annual three-cutting system. Grass samples are taken periodically during the growing season to determine the plant dry matter accumulation and uptake of N, P and K.

Palazzo, A.J., T.F. Jenkins and C.J. Martel (1981) Vegetation selection and management for overland flow systems. Public Works, vol. 112, no. 8, p. 49-52.

This paper details the usefulness of several forage grasses on an overland flow system operated in Hanover, New Hampshire. Also discussed are the problems encountered with invading species and winter operation, how to maintain the cover crop prior to land treatment, and the yield that may be expected. General recommendations include the specific grass mixes to use, when to fertilize and proper weed control.

Riggan, P.J. and D.W. Cole (1981) Simulation of forest production and nitrogen uptake in a young Douglas Fir ecosystem. Chap. 15. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 410-443.

This chapter presents a model for biomass production and N uptake in a Douglas fir ecosystem. The model is evaluated with field data from Pack Forest experimental site near Seattle, Washington.

Ryden, J.C., L.J. Lund and S.A. Whaley (1981) Direct measurement of gaseous nitrogen losses from an effluent irrigation area. Journal of the Water Pollution Control Federation, vol. 53, p. 1677-1682.

This study measures the extent and nature of gaseous N loss from an effluent disposal area following irrigation with secondary-treated effluent. Gaseous N losses from field plots within the disposal area are estimated from measurements of NH_4^+ volatilization and total denitrification N loss using a field adaptation of the acetylene-inhibition technique.

Ryden, J.C., J.K. Syers and I.K. Iskandar (1981) Evaluation of a simple model for predicting phosphorus removal by soils during land treatment of wastewater. Chap. 22. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 647-667.

This chapter describes a simple model that evaluates soils' ability to remove wastewater P, and predicts P movement in soils and site longevity. The model is evaluated with field data; advantages and limitations of the model are discussed.

Selim, H.M. and I.K. Iskandar (1981) WASTEN: A model for nitrogen behavior in soils irrigated with liquid waste. In Simulation of Nitrogen Behavior of Soil-Plant Systems (M.J. Frissel and J.A. van Veen, Eds.). Wageningen, the Netherlands: Pudoc, Centre for Agricultural Publishing and Documentation.

This model 1) simulates the physical, chemical and biological processes of N transformation and transport in multilayered soil profiles for slow and rapid infiltration systems, 2) enables prediction of NO_3^--N concentrations in soil solution and leachate in time and space, and 3) assists in esti-

mating the application rate and schedule of water and N to a land treatment system.

Selim, H.M. and I.K. Iskandar (1981) A model for predicting nitrogen behavior in slow and rapid infiltration systems. Chap. 17. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 478-507.

This chapter presents a mechanistic N model that includes a water submodel and an N submodel. The effects of nitrification rate, NH_4^+ exchange, plant uptake, wastewater application rate and schedule, and rainfall are discussed in terms of the models' sensitivity.

Selim, H.M. and I.K. Iskandar (1981) Modeling nitrogen transport and transformation in soils: 1. Theoretical considerations. Soil Science, vol. 131, p. 233-241.

This paper is a condensed version of Chapter 17 by Selim and Iskandar in Modeling Wastewater Renovation - Land Treatment.

Shaffer, M.J. and S.C. Gupta (1981) Hydrosalinity models and field validation. Chap. 7. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 136-181.

This chapter presents a review of hydrosalinity models for land treatment and discusses the Bureau of Reclamation model. Model sensitivity analysis and evaluation are also included using data from three different systems and simulated field applications.

Smith, C.J., R.L. Chen and W.H. Patrick, Jr. (1981) Nitrous oxide emission from simulated overland flow wastewater treatment systems. Soil Biology and Biochemistry, vol. 13, p. 275-278.

This study looks at N_2O evolution from overland flow prototypes receiving daily applications of municipal wastewater with NH_4^+-N concentrations of 10 to 47 µg/mL. The effect of liming the soil and increasing the NH_4^+ concentration in the wastewater is also studied.

Stanley, P.M. and E.L. Schmidt (1981) Serological diversity of Nitrobacter spp. from soil and aquatic habitats. Applied and Environmental Microbiology, vol. 41, p. 1069-1071.

This study examines the serological diversity among Nitrobacter spp. Fluorescent antibodies prepared against 11 Nitrobacter spp. cultures isolated from soil and water are placed in six serogroups. These fluorescent antibodies are compared with a group of 16 additional isolates.

Syers, J.K. and I.K. Iskandar (1981) Soil phosphorus chemistry. Chap. 20. In Modeling Wastewater Renovation - Land Treatment (I.K. Iskandar, Ed.). New York: John Wiley and Sons, p. 571-599.

This chapter reviews the literature on soil P chemistry as related to land treatment. Emphasis is given to sorption-desorption reactions since these have direct bearing on the movement of P within soils and influence the longevity of sites for wastewater renovation.

U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Department of Interior and U.S. Department of Agriculture (1981) Process Design Manual for Land Treatment of Municipal Wastewater. EPA 625/1-81-013 (COE EM 1110-1-501).

This manual provides criteria and supporting information for the planning and process design of land treatment systems. Recommended procedures for planning and design are presented along with state-of-the-art information on treatment performance, energy considerations, and health and environmental effects. This document is a revision of the Process Design Manual for Land Treatment of Municipal Wastewater sponsored by EPA, COE and USDA, and published in 1977. The scope of this manual is limited to the three major land treatment processes: slow rate, rapid infiltration and overland flow.

Technical reports

Abele, G., H.L. McKim, D.M. Caswell and B.E. Brockett (1981) Hydraulic characteristics of the Deer Creek Lake land treatment site during wastewater application. CRREL Report 81-7 (ADA 103 732).

The objectives of this study are to determine the infiltration and drainage rates at the Deer Creek Lake land treatment system outside of Columbus, Ohio, and the total water mass balance during wastewater application. Previous soil water-content data were conflicting so the wastewater distribution on the application area is examined in this report.

Jenkins, T.F. and A.J. Palazzo (1981) Wastewater treatment by a slow rate land application system. CRREL Report 81-14 (ADA 106 975).

Six slow rate land treatment prototypes, three containing a sandy loam and three containing a silt loam, are studied from June 1974 to May 1980. The systems are spray-irrigated with either primary or secondary wastewater at varying application rates. The performance of forage grasses is studied to determine the yield and nutrient uptake under the various application regimes.

Jenkins, T.F., D.C. Leggett, C.J. Martel and H.E. Hare (1981) Removal of volatile trace organics from wastewater by overland flow. CRREL Special Report 81-1 (ADA 097 576).

A prototype overland flow land treatment system is studied to determine its effectiveness in reducing the levels of volatile trace organics in municipal wastewater. Chlorinated primary wastewater, water collected from the surface at various points downslope, and runoff are analyzed by GC-MS using a purge and trap sampler.

Jenkins, T.F., A.J. Palazzo, P.W. Schumacher, H.E. Hare, P.L. Butler, C.J. Diener and J.M. Graham (1981) Seven-year performance of CRREL slow-rate land treatment prototypes. CRREL Special Report 81-12 (ADA 103 739).

Water quantity and quality data are presented for the wastewater applied to and the percolate leaving the 5-ft soil profiles of six outdoor test cells that were operated from June 1973 through May 1980. Average concentration, mass loading, mass removal and percentage removal of wastewater constituents are presented for each year. Nutrient balance sheets summarize the relative amounts removed by plant uptake, deep percolation and other N and P removal mechanisms.

Palazzo, A.J. and J.M. Graham (1981) Seasonal growth and uptake of nutrients by orchardgrass irrigated with wastewater. CRREL Report 81-8 (ADA 101 613).

This 2-year field study determines the seasonal growth and nutrient accumulation of a forage grass receiving primary treated domestic wastewater. An established sward of Pennlate orchardgrass is managed on an annual three cutting system. Grass samples are periodically analyzed to determine plant dry matter accumulation and uptake of N, P and K. Changes in nutrient uptake with harvest period are related to both changes in dry matter accumulation and plant nutrient concentration. Estimates of monthly plant removal for N and P are presented as a guide in designing land treatment systems according to the procedures given in the Process Design Manual for Land Treatment of Municipal Wastewater (EM 1110-1-501).

Parker, L., I.K. Iskandar and D.C. Leggett (1981) Effect of soil temperature and pH on nitrification kinetics in soils receiving a low level of ammonium enrichment. CRREL Special Report 81-33 (ADA 090 575/2).

Two studies investigate the effect of soil temperature and pH on nitrification kinetics in soils receiving a low level of NH_4^+ enrichment. Soil samples are analyzed for NH_4^+, NO_2^- and NO_3^-. In the temperature study the number of NH_4^+ and NO_2^- oxidizers is also determined. In this study two soils from a slow infiltration land treatment test facility are used. The three incubation temperatures selected mimic field conditions at the test site. Soils that had received prior treatment with dolomitic limestone to raise the pH are used in the second study to determine the effect of pH on

nitrification kinetics. The three pHs used in this study are 4.5, 5.5 and 7.0.

Peters, R.E., C.R. Lee and D.J. Bates (1981) Field investigation of overland flow treatment of municipal lagoon effluent. USAEWES Technical Report EL-81-9.

Overland flow treatment of municipal lagoon effluent is studied in a field environment near Utica, Mississippi. The ability of overland flow to renovate municipal wastewater with respect to BOD, TSS, nutrients, fecal coliforms and heavy metals is studied over an approximately 3-year period. The roles played by soil, soil temperature, vegetative cover and management in wastewater renovation are investigated.

Ryan, J.F and R.C. Loehr (1981) Site selection methodology for the land treatment of wastewater. CRREL Special Report 81-28 (ADA 108 636).

This report presents a methodology that covers various facets of site selection, from preliminary screening to field data acquisition for the preparation of a final design for a land treatment system. The methodology is presented in three stages or levels.

1980 ENTRIES

Publications in open literature

Belser, L.W. and E.L. Schmidt (1980) Growth and oxidation kinetics of three genera of ammonia oxidizing nitrifiers. FEMS Microbiology Letters, vol. 7, p. 213-216.

This article presents data on parameters that characterize the growth and kinetics of substrate oxidation for three genera of NH_4^+ oxidizers (Nitrosomonas, Nitrosospira, Nitrosolobus). Comparative studies based on the MPN and FA enumeration techniques in pure culture are used to obtain the results.

Chen, R.L. and W.H. Patrick, Jr. (1980) Nitrogen transformations in a simulated overland flow wastewater treatment system. Water Research, vol. 14, p. 1041-1046.

In this study physical scale models of plant-soil systems and labeled $^{15}N\text{-}NH_4^+$ are used to determine the fate of applied N during overland flow. Of special interest is the N removal efficiency and the amount of applied N incorporated into the plant-soil system.

Iskandar, I.K. and J.K. Syers (1980) Effectiveness of land application for phosphorus removal from municipal waste water at Manteca, California. Journal of Environmental Quality, vol. 9, no. 4, p. 616-621.

This study evaluates the effectiveness of P removal by a slow infiltration system that has been in operation for several years and discusses the results obtained in terms of the soil characteristics. The effects of crop removal, infiltration rate and the P sorption capacity of the soil are discussed.

Jacobson, S.N. and M. Alexander (1980) Relation of temperature, carbon source, and denitrifier population to nitrate loss from soil. Soil Biology and Biochemistry, vol. 12, p. 501-505.

This study develops practical means for the use of soil in removing NO_3^- and organic matter from wastewater. The soils and conditions are selected to estimate the likely effect of environmental or operating conditions in the field on the rate of NO_3^- removal. In addition, a quantitative relation is sought between the numbers of denitrifiers and the extent of NO_3^- reduction in the soil.

Jenkins, T.F., D.C. Leggett and C.J. Martel (1980) Removal of volatile trace organics from wastewater by overland flow treatment. Journal of Environmental Sciences and Health, vol. 15, no. 3, p. 211-224.

A prototype overland flow land treatment system is studied to determine its effectiveness in reducing the levels of volatile trace organics in municipal wastewater. Chlorinated primary wastewater, water collected from the surface at various points downslope and runoff are analyzed by GC-MS using a purge and trap sampler.

Jenkins, T.F., D.C. Leggett, C.J. Martel, R.E. Peters and C.R. Lee (1980) Toxic volatile organics removal by overland flow land treatment. In Proceedings, 53rd Annual Conference of Water Pollution Control Federation, September 28-October 3, Las Vegas, Nevada. Washington, D.C.: Water Pollution Control Federation.

This study determines the degree and rate of removal by overland flow for a number of toxic organic substances and develops relationships for predicting removals. Two sites were used in this study, one in Hanover, New Hampshire, and the other in Utica, Mississippi. This study is a follow-up to the one published in the Journal of Environmental Sciences and Health (1980).

Martel, C.J., D.D. Adrian, T.F. Jenkins and R.E. Peters (1980) Rational design of overland flow systems. Proceedings, 1980 American Society of Civil Engineers National Conference on Environmental Engineering, July 8-10, New York. New York: ASCE.

This paper presents a design procedure based on hydraulic detention time (the average time a particle of water takes to travel from the top to the bottom of the slope). The authors theorize that any desired level of treatment can be achieved by controlling the length of time wastewater remains on the slope.

Marten, G.C. and A.W. Hovin (1980) Harvest schedule, persistence, yield, and quality interactions among four perennial grasses. Agronomy Journal, vol. 72, p. 378-387.

This paper determines whether harvest schedule under weed-free conditions differentially influences persistence, hay yield and forage quality for orchardgrass, tall fescue, reed canarygrass and smooth bromegrass.

Marten, G.C., W.E. Larson and C.E. Clapp (1980) Effects of municipal wastewater effluent on performance and feed quality of maize vs. reed canarygrass. Journal of Environmental Quality, vol. 9, p. 137-141.

This study compares the feed quality and yields of maize fodder and reed canarygrass when managed by conventional practices and when treated with municipal wastewater during four growing seasons.

Marten, G.C., D.R. Linden, W.E. Larson and C.E. Clapp (1980) Maize culture in reed canarygrass sod to renovate municipal wastewater effluent. Agronomy Journal, vol. 73, p. 293-297.

These two experiments are conducted over a 3-year period on effluent-treated soils and assess the effects of suppressing reed canarygrass with several types and rates of herbicides on 1) yields of interplanted maize grain and fodder, 2) total crop yields and N removal by maize-reed-canarygrass combinations, 3) feed quality of interplanted maize, 4) water infiltration capacity of Typic Hapludoll soil, and 5) the N concentration in the soil water at the bottom of the root zone (just above the water table).

Meals, D.W., Jr., E.A. Cassell, J.R. Bouzoun and C.J. Martel (1980) Spray application of wastewater effluent in West Dover, Vermont. Journal of the New England Water Pollution Control Association, vol. 14, no. 1, p. 38-53.

This paper evaluates performance of the land treatment process in West Dover, including considerations of the hydrologic behavior of the site, treatment effectiveness, patterns of seasonal variation and off-site effects. This treatment plant disposes of chlorinated effluent by spraying on forested land and is one of the few in the U.S. that operates year-round in a cold climate.

Nakano, Y. (1980) Application of recent results in functional analysis to the problem of wetting fronts. Water Resources Research, vol. 16, no. 2, p. 314-318.

Some recent results in nonlinear functional analysis are presented as evidence supporting the new viewpoint that wetting fronts with a finite propagating speed are generally singular surfaces.

Palazzo, A.J., C.J. Martel and T.F. Jenkins (1980) Forage grass growth on overland flow systems. In Proceedings of the 1980 American Society of Civil Engineers National Conference on Environmental Engineering, July 8-10, New York. New York: ASCE, p. 347-354.

This study 1) determines plant growth and nutrient removal on an overland flow slope receiving primary or secondary effluent, 2) provides information for the improvement of plant management procedures for maintaining maximum plant uptake of N and P, and 3) ascertains the feed quality and value of the plant material grown.

Stark, S.A. and C.E. Clapp (1980) Residual nitrogen availablity from soils treated with sewage sludge in a field experiment. Journal of Environmental Quality, vol. 9, no. 3, p. 505-512.

The residual N available from sewage sludges applied to a sandy loam soil is determined in this study. In study I, three sludge types--anaerobically digested, aerobically digested, and mixed primary-settled and waste-activated--are applied over a 3-year period. Soil samples are collected 2 years after the final sludge application. Study II samples are obtained from plots of a field experiment in which an anaerobically digested sludge had been applied 4 years earlier. Several biological and chemical characteristics are examined as indexes of N availability.

Technical Reports

Abele, G., H.L. McKim, B.E. Brockett and J. Ingersoll (1980) Infiltration characteristics of soil at Apple Valley, Minnesota, Clarence Cannon Dam, Montana, and Deer Creek Lake, Ohio. CRREL Special Report 80-36 (ADA 093 350).

Three land treatment sites at Apple Valley, Minnesota, Clarence Cannon Dam, Missouri, and Deer Creek Lake, Ohio, are used to collect and evaluate field infiltration data. This study also evaluates the installation and operation of the test equipment and instrumentation, as well as data collection schedule and analysis techniques.

Chen, R.L. and W.H. Patrick, Jr. (1980) Nitrogen transformation in a simulated overland flow wastewater treatment system. CRREL Special Report 80-16 (ADA 084 280).

This research employs scale models of plant-soil systems in which labeled ^{15}N (as NH_4^+-N) is used to trace applied N during overland flow. The N removal efficiency and the amount of applied N incorporated in the plant-soil system are of special interest.

Hoeppel, R.E., R.G. Rhett and C.R. Lee (1980) Fate and enumeration problems of fecal coliform bacteria in runoff wa ers from terrestrial ecosystems. USAEWES Technical Report EL-80-9 (ADA 090 719).

Field and greenhouse model tests are conducted, using both natural wastewater and tracer fecal coliform bacteria. Greenhouse models use soils that are either uncontaminated or contaminated by human wastes; application rates are varied to determine best treatment conditions. The standard method for fecal coliform testing is modified to develop improved testing methodology.

Iskandar, I.K., L. Parker, K. Madore, C. Gray and M. Kumai (1980) Disinfection of wastewater by microwaves. CRREL Special Report 80-1 (ADA 082 174).

This report explores microwave radiation as a possible alternative for disinfection of wastewater and investigates the rate and extent of disinfection and possible mechanisms of bacterial destruction.

Iskandar, I.K., L. Parker, C. McDade, J. Atkinson and A.P. Edwards (1980) Dynamics of NH_4 and NO_3 in cropped soils irrigated with wastewater. CRREL Special Report 80-27 (ADA 090 575).

This field study 1) obtains information on the dynamic behavior of wastewater NH_4^+ and NO_3^- in soils, 2) determines the relative abundance of NH_4^+ and NO_3^- in soils receiving wastewater, and 3) evaluates any seasonal effect on the fate of wastewater NH_4^+ applied to soils in a slow infiltration system. The study is conducted using an on-going test plot with two soil types and a forage grass cover.

Leggett, D.C. and I.K. Iskandar (1980) Improved enzyme kinetic model for nitrification in soils amended with ammonium: I. Literature review. CRREL Report 80-1 (ADA 082 303).

This work synthesizes reported temperature and pH effects on nitrification and nitrifier growth rates. The principles of microbial kinetics are extended to soils.

Martel, C.J., T.F. Jenkins and A.J. Palazzo (1980) Wastewater treatment in cold regions by overland flow. CRREL Report 80-7 (ADA 084 489).

In this study primary effluent, secondary effluent and tapwater are applied to separate sections of a pilot-scale overland flow site in a cold

regions environment. Performance is evaluated for 1 year, May 1977 to June 1978.

Nakano, Y. (1980) Propagating velocity of singularity occurring in certain degenerate parabolic equations. Transactions of the Twenty-fifth Conference of Army Mathematicians. Research Triangle Park, N.C.: Army Research Office, ARO Report 80-1.

The conditions that determine the propagating velocity of a wetting front and also serve as the moving boundary conditions at the wetting front are presented. These conditions are shown to hold true for particular solutions reported in the literature.

Selim, H.M. and I.K. Iskandar (1980) Simplified model for prediction of nitrogen behavior in land treatment of wastewater. CRREL Report 80-12 (ADA 085 191).

A simplified model for simulation of N transformations and transport in land treatment is presented. The purpose of the model is to predict the behavior of NH_4^+-N and NO_3^--N in the soil profile in land treatment systems. The model is based on the simultaneous solution of the transient soil water flow equation with the equations describing the transformation, transport and plant uptake of N in the soil. The model is valid for uniform as well as multilayered soil profiles and can be adapted to incorporate various N transformation mechanisms and boundary conditions.

Theses and dissertations

Gasiorowski, S.A. (1980) Phosphate adsorption and desorption on two contrasting soils used for land treatment of wastewater. Ph.D. Dissertation, University of New Hampshire, Durham.

This research involves the phosphate adsorption-desorption behavior of two soils: Charlton silt loam, a typical acid soil from New England which is being used in experimental wastewat . treatment, and Tujunga coarse sandy loam from a wastewater treatment facility located at Manteca, California, which has failed to remove phosphate from wastewater efficiently. The effects of altering the pH and phosphate content of municipal wastewater on adsorption and desorption are determined. Radioactive ^{32}P is used to follow the adsorption and desorption rate in suspensions of soil and wastewater. Parallel experiments are conducted where phosphate is also monitored by conventional spectrophotometric analyses. The complementary use of ^{32}P and non-radioactive phosphate permits the evaluation of adsorption and desorption of freshly sorbed and native phosphate independently, as well as evaluation of the degree of exchange.

Greene, S.M. (1980) Formation of dimethylnitrosamine during treatment of municipal wastewater by simulated land application. M.S. Thesis, Cornell University, Ithaca, New York.

This study is designed to establish the potential risk of nitrosamine formation during land treatment. Dimethylnitrosamine (DMNA) is selected because of its extreme toxicity and the ubiquity of its precursor amine. The behavior of NO_2^- and dimethylamine (DMA) in relation to DMNA formation is studied. The yield of DMNA is examined in two acidic, sewage amended soils: Arkport fine sandy loam and Lake George sand. The latter soil is obtained from a site that had received amendments of municipal wastewater for 20 years. DMNA levels are also measured in sewage that had been percolated through 15-cm soil columns, and predictions are made from these data about the possibility of nitrosamine contamination of groundwater. Factors that might contribute to the risk of nitrosamine formation during land application of wastewater are examined.

Presentations

Adams, J.R. and C.J. Merry (1980) Application of a land resource information system (LRIS) and the CAPDET model to facilities planning and land treatment of municipal wastewater. Presented at the 14th International Symposium on Remote Sensing of Environment, 23-30 April, San Jose, Costa Rica.

This paper discusses the combined use of a large computer database (LRIS) and a computer model (CAPDET). The LRIS allows the rapid evaluation of very large land areas for suitability for any land use that can be evaluated in terms of physical soil properties. (CAPDET provides information for evaluation of the economics of a variety of wastewater treatment systems.) In this study, the portion of the Lake Erie drainage basin located in the U.S. is evaluated to determine whether it contains potential sites for land treatment.

Cole, D.W. (1980) Response of forest ecosystems to sludge and wastewater applications - A case study in western Washington. Presented at the Symposium on Utilization of Municipal Wastewater and Sludge for Land Reclamation and Biomass Production, September 16-18, Pittsburgh, Pennsylvania.

The purpose of the program at the University of Washington is to investigate the feasibility of applying municipal wastewater and dewatered sludge to established forests and new plantations. This paper addresses the three major goals of this program: 1) to determine the environmental soundness of the program, 2) to determine changes in forest productivity, 3) and to establish the economic aspects, including both costs and benefits.

Jenkins, T.F., D.C. Leggett and C.R. Lee (1980) Toxic volatile organics removal by overland flow land treatment. Presented at the 53rd Annual Conference of the Water Pollution Control Federation, September 28 - October 3, Las Vegas, Nevada.

The ability of overland flow systems to treat and remove toxic volatile organics from wastewater is studied at sites in Utica, Mississippi, and Hanover, New Hampshire. The percent removal is found to be a function of detention time. Biodegradation, sorption on suspended matter and volatilization are discussed as possible mechanisms of removal.

Martel, C.J., D.D. Adrian and R.E. Peters (1980) Design of overland flow systems--A rational approach. Presented at the 53rd Annual Conference of the Water Pollution Control Federation, September 28 - October 3, Las Vegas, Nevada.

This paper presents a rational procedure for design of overland flow systems. With this procedure, overland flow systems can be designed to meet discharge permit requirements.

Martel, C.J., J.R. Bouzoun and T.F. Jenkins (1980) Removal of organics by overland flow. Presented at the U.S. Environmental Protection Agency National Seminar on Overland Flow Technology for Municipal Wastewater, September 16-18.

This study is conducted to better understand the behavior of and possible mechanisms for selected removal of organics in overland systems, and the kinetics of their removal. This paper focuses on the BOD, TOC and trace organic removal findings.

Palazzo, A.J. and J.R. Bouzoun (1980) Long-term plant nutrient removal using the nutrient film technique for wastewater treatment. Proceedings, 72nd Meeting, American Society of Agronomy, November 30 - December 5, Detroit, Michigan, p. 33.

This study determines the effectiveness of the nutrient film technique as a wastewater treatment system. Primary domestic wastewater is applied continuously for 190 days to mature reed canarygrass. The N, P, K, crude protein and dry matter yield of the plants are examined along with the N and P levels in the applicant and runoff (abstract only).

Parker, L. and I.K. Iskandar (1980) Effects of temperature and pH on nitrification kinetics in soils. Proceedings, 72nd Annual Meeting, American Society of Agronomy, November 30 - December 5, Detroit, Michigan, p. 34.

The effect of temperature on nitrification kinetics in soils at a low N concentration is monitored microbiologically and chemically. This study is performed on two New Hampshire soils. The effect of pH is tested in three Wisconsin soil samples. The microbiological population is not monitored in this experiment (abstract only).

1979 ENTRIES

Publications in open literature

Breuer, D.W., D.W. Cole and P. Schiess (1979) Nitrogen transformation and leaching associated with wastewater irrigation in Douglas-fir, poplar, grass and unvegetated systems. In Municipal Wastewater and Sludge Recycling on Forest Land and Disturbed Land (W.E. Sopper, Ed.). University Park: Pennsylvania State University Press, p. 19-33.

This study evaluates the N transformations and transport process in coniferous and deciduous forests. The study includes an experimental system at Pack Forest near Seattle, Washington, and gives an overview of the site and initial results on the nitrification process and N leaching characteristics.

Hunt, P.G., R.E. Peters, T.C. Sturgis and C.R. Lee (1979) Reliability problems with indicator organisms for monitoring overland flow treated wastewater effluent. Journal of Environmental Quality, vol. 8, p. 301-304.

A 2-year study (1975-76) on the response of indicator organisms in wastewater from faculative lagoons treated by overland flow is conducted in Utica, Mississippi. Fecal streptococci and fecal coliforms are enumerated in the wastewater before it is applied to the plots, as it flows downslope and as it is discharged from the plots.

Johnson, D.W., D.W. Breuer and D.W. Cole (1979) The influence of anion mobility on ionic retention in wastewater-irrigated soils. Journal of Environmental Quality, vol. 8, no. 2, p. 146-250.

This paper offers a conceptual model of soil leaching mechanisms and provides baseline information that may be used to develop land treatment design guidelines incorporating total environmental fluxes. All the major anions are considered collectively. Their production and mobility are related to the total ionic leaching following irrigation of municipal wastewater on a forest soil.

Lee, C.R. and R.E. Peters (1979) Overland flow treatment of a municipal lagoon effluent for reduction of nitrogen, phosphorus, heavy metals,

and coliforms. Journal of Progress in Water Technology, vol. 11, p. 175-183.

Overland flow treatment of municipal facultative lagoon effluent is studied on 24 research plots at Utica, Mississippi. The study evaluates factors such as the amount of wastewater applied, length of application period, slope of treatment area, crop management, and reduction in BOD, SS, N, O, heavy metals and coliforms.

Marten, G.C., C.E. Clapp and W.E. Larson (1979) Effects of municipal wastewater effluent and cutting management on persistence and yield of eight perennial forages. Agronomy Journal, vol. 71, p. 650-658.

The persistence and yields of dry matter and feed nutrients of seven cool-season perennial grasses and alfalfa are determined using three cutting schedules. Two levels of effluent treatment plus one control treatment--commercial fertilizer--are used in this study, which covers a 5-year period.

McKim, H.L., T.F. Jenkins, C.J. Martel and A.J. Palazzo (1979) International and national developments in land treatment of wastewater. In Symposium on Effluent Irrigation Under Prairie Conditions, 24-25 January, Regina, Saskatchewan. Environment Canada.

This paper documents the national and international history and scope of land treatment. The types of land treatment discussed are rapid infiltration, slow infiltration and overland flow. Specific examples are used. The primary design criteria, management practices and treated water quality characteristics are discussed.

Nakano, Y. (1979) Application of recent results in functional analysis to the problems of water tables. Advances in Water Resources, vol. 2, p. 185-190.

The traditional viewpoint in hydrology and soil physics purports that water tables appearing in porous media described by Darcy's law and the extended Darcy's law are not singular surfaces. Several particular solutions in which singularities occur are presented as counter-examples to the traditional viewpoint and as evidence supporting the new theory that water tables are generally singular surfaces.

Nakano, Y., R.A. Khalid and W.H. Patrick Jr. (1979) Water movement in a land treatment system of wastewater by overland flow. Progress in Water Technology, vol. 11, no. 4-5, p. 185-206.

Water movement in an overland flow land treatment system is studied experimentally and theoretically. A small-scale physical model is used to obtain experimental data. The theoretical analysis is based upon the

shallow water equation for overland flow and the Darcy-Richards law for soil water flow.

Palazzo, A.J. and T.F. Jenkins (1979) Land application of wastewater: Effect on soil and plant potassium. Journal of Environmental Quality, vol. 8, p. 309-312.

This study reports on the removal of K by a forage grass mixture from soil that received applications of wastewater over a 5-year period. The forages were grown on either sandy loam or silt loam soil.

Technical Reports

Abele, G., H.L. McKim and B.E. Brockett (1979) Mass water balance during spray irrigation with wastewater at Deer Creek Lake land treatment site. CRREL Special Report 79-29 (ADA 080 649).

The water mass balance for a 3.6-ha test area is calculated during and two days after wastewater application. The total water mass balance is calculated by use of soil water contents, underdrain flow rates and calculated values for evapotranspiration.

Bausum, H.T., R.E. Bates, H.L. McKim, P.W. Schumacher, B.E. Brockett and S.A. Schaub (1979) Bacterial aerosols from a field source during multiple sprinkler irrigation: Deer Creek Lake State Park, Ohio. CRREL Special Report 79-32 (ADA 077 632).

Quantitative data on the strength, dispersion, particle size and decay of bacterial aerosols produced downwind from a spray irrigation land treatment system are presented in this study.

Bouzoun, J.R. (1979) Freezing problems associated with spray irrigation of wastewater during the winter. CRREL Special Report 79-12 (ADA 070 031).

This report assesses the problems associated with applying wastewater by spray irrigation during the winter in a cold climate. The system discussed in this report is the wastewater treatment facility in West Dover, Vermont.

Cassell, E.A., D.W. Meals, Jr. and J.R. Bouzoun (1979) Spray application of wastewater effluent in West Dover, Vermont: An initial assessment. CRREL Special Report 79-6 (ADA 068 534).

This study assesses the performance of the land treatment system in West Dover, Vermont. This 6-week monitoring program is designed to determine the amounts of N, P and other constituents applied to the eastern slope of

the effluent spray field and to determine the amounts of these constituents in drainage from the spray field. Site performance is assessed in terms of mass balance of various nutrient forms across the eastern slope. In addition, data on site groundwater and adjacent streams are collected and examined to provide an initial estimate of the impact of effluent application.

Elgawhary, S.M., I.K. Iskandar and B.J. Blake (1979) Evaluation of nitrification inhibitors in cold regions land treatment of wastewater: Part 1. Nitrapyrin. CRREL Special Report 79-18 (ADA 071 077).

A series of laboratory and field tests are conducted to investigate the possibility that nitrapyrin could be useful as a nitrification inhibitor in land treatment. Laboratory tests included soil incubation and soil column studies. Variables were soil type, temperature, nitrapyrin concentration and method of application to the soil. Experimental designs included two soils, three temperatures and three levels of inhibitors in a complete factorial. Forage grasses were present in all treatments, and wastewater containing NH_4^+ was used.

Iskandar, I.K., S.T. Quarry, R.E. Bates and J. Ingersoll (1979) Documentation of soil characteristics and climatology during five years of wastewater application to CRREL test cells. CRREL Special Report 79-23 (ADA 074 712).

This report is a collection of information gathered during 5 years of a field study on slow infiltration land treatment. Emphasis is on presenting actual data as well as detailed descriptions of the methods used. Very little discussion is included.

Jacobson, S.N. and M. Alexander (1979) Preliminary investigations of the kinetics of nitrogen transformation and nitrosamine formation in land treatment of wastewater. CRREL Special Report 79-4 (ADA 086 169).

Denitrification of NO_3^- in wastewater is monitored in soils with pHs of 4.2, 5.5 and 6.8. The effects of C sources on the denitrification rates (glucose, methanol, succinate or secondary effluent) are monitored in a sandy loam and a silty loam soil.

Jenkins, T., H. Hare, A. Palazzo, R. Bates, C. Martel, I. Iskandar, D. Fisk, D. Gaskin, P. Shumacher, J. Bayer, S. Quarry, J. Ingersoll, L. Jones and J. Graham (1979) Prototype overland flow test data: June 1977 - May 1978. CRREL Special Report 79-35 (ADA 078 734).

This study presents data from a 1-year study on a prototype overland flow land treatment system. Water quantity and quality data are presented as well as plant yields and nutrient uptake. The soil chemical and physical parameters measured are also presented along with a table of initial site

characteristics. The meteorological measurements obtained in support of this effort are included to complete the data base.

Jenkins, T.F., S.T. Quarry, I.K. Iskandar, A.P. Edwards and H.E. Hare (1979) Use of ^{15}N to study nitrogen transformations in land treatment. CRREL Special Report 79-31 (ADA 077 583).

This study compares different strategies of using ^{15}N as a tracer in describing the fate of wastewater N in land application. Four soil columns are packed with a sandy loam soil and covered with forage grass. The columns are treated with tapwater or wastewater according to four experimental strategies. The strategies vary the treatment given the soil prior to application of the ^{15}N label, the schedule and amounts of the applied ^{15}N label, and the type of water used for subsequent column leaching.

Theses

Cantor, R.R. (1979) Denitrification studies at Deer Creek State Park wastewater renovation site. M.S. Thesis, Ohio State University, Columbus.

This study employs the acetylene inhibition technique as a laboratory and in situ method of measuring denitrification. Laboratory studies include 1) checks on the accuracy of lab studies, and 2) tests to determine the effects of glucose, NO_3^- and moisture content on denitrification and the effect of headspace N_2O on N_2O evolution. In situ denitrification studies are performed on tilled alfalfa and reed canarygrass plots. The effect of soil organic levels on denitrification is determined for these plots. The relative effects that plant uptake and denitrification have on wastewater renovation is determined for each plot. The exudation of carbonaceous material by each crop is also assessed for its effect on denitrification.

Chopp, K.M. (1979) Microbial populations and activity in soil irrigated with municipal wastewater effluent. M.S. Thesis, University of Minnesota, St. Paul.

Nitrification in soil and the conditions that affect it are discussed. The following topics are covered: 1) the best procedure for extracting NH_4^+ oxidizing bacteria from soil, 2) the optimum method of enumerating NH_4^+ oxidizing bacteria, 3) the effects of treatment, season, crop and crop residue on soil microbe numbers and activity, with an emphasis on NH_4^+ oxidizing bacteria, 4) the relationships that exist between microbial numbers and activity, especially the relationship of nitrifying bacteria with soil and water N concentrations.

Moser, M.A. (1979) Methodology for assessing soil series suitability for land treatment of wastewater. M.S. Thesis, Cornell University, Ithaca, New York.

Methodology is developed to rate soil series suitability for slow rate, overland flow and rapid infiltration land treatment based on soil information available in soil surveys. Soil properties affecting wastewater transmission and pollutant attenuation are reviewed and summarized. Commonly available information on soil properties is characterized for importance to assessing soil suitability for land treatment processes.

Presentations

Clapp, C.E., G.C. Marten, D.R. Linden and W.E. Larson (1979) Nutrient uptake by crops irrigated with municipal wastewater effluent. Proceedings, 71st Annual Meeting, American Society of Agronomy, 5-10 August, Fort Collins, Colorado, p. 27.

Plant nutrient uptake by corn and forage grasses is compared when these crops are irrigated with secondary municipal wastewater or treated with inorganic fertilizer for a 4-year period. Total seasonal N uptake curves for crops irrigated with effluent, including corn, reed canarygrass and other selected forage grasses, are presented. N uptake with time within seasons by corn and forage grasses are graphically illustrated. Plant uptake of P, Ca, Mg and Na is also discussed (abstract only).

Dowdy, R.H., C.E. Clapp, W.E. Larson and D.R. Duncomb (1979) Runoff and soil water quality as influenced by five years of sludge applications on a terraced watershed. Proceedings, 71st Annual Meeting, American Society of Agronomy, 5-10 August, Fort Collins, Colorado, p. 28.

The effects of applying municipal sewage sludge on a terraced watershed over a 5-year period are examined. The heavy metal content (Zn, Cr, Cu, Pb, Ni and Cd) the runoff and soil water at depths of 60 and 150 cm is determined. The area cropped with corn receives liquid sludge by surface injection and the area cropped with reed canarygrass receives it by sprinkler irrigation (abstract only).

Iskandar, I.K. (1979) Selected design parameters of existing systems for land application of liquid waste: A computer file. Presented at the 2nd Annual Conference on Municipal Waste Management, September 17-21, Madison, Wisconsin.

This computer file and accompanying programs store and retrieve information on design parameters, performance characteristics and published information on existing land treatment systems. This file should assist design engineers during the planning of new land treatment systems.

Iskandar, I.K. and H.M. Selim (1979) Validation of a mathematical model for nitrogen transformations and transport in land treatment of

wastewater. Proceedings, 71st Annual Meeting, American Society of Agronomy, 5-10 August, Fort Collins, Colorado, p. 30.

Soil lysimeters are used to investigate the effectiveness of N removal. These results are used as a data base for the validation of a simplified N model. The model predicts the transport and transformations of NH_4^+ and NO_3^- in a multilayered soil profile under transient water flow conditions. The model also includes water and N uptake by plants (abstract only).

Iskandar, I.K., C. McDade, L.V. Parker and A.P. Edwards (1979) Inorganic nitrogen and forage root distribution in soils irrigated with wastewater. Proceedings, 71st Annual Meeting, American Society of Agronomy, 5-10 August, Ft. Collins, Colorado, p. 30.

This field study determines the dynamics of NH_4^+ and NO_3^- in soils irrigated weekly with domestic wastewater. Soil cores, to 60-cm deep, are collected from two plots containing different soil types. The samples are collected in July and October for NH_4^+ and NO_3^- analyses. Root length, diameter and distribution with soil depth are determined in samples collected in July, October and December. The effect of soil depth and temperature (season) on NH_4^+, NO_3^- and root distribution is discussed (abstract only).

McKim, H.L. and G. Abele (1979) Performance of a slow infiltration land treatment system at Deer Creek Lake, Ohio. Proceedings, 71st Annual Meeting, American Society of Agronomy, 5-10 August, Fort Collins, Colorado, p. 33.

This study examines the effect of application of wastewater from a holding pond to three 1.2-ha test sites having reed canarygrass, alfalfa and oat-soybean rotation. The P and NO_3^- concentrations in the applied wastewater and percolate are examined. The dry yields and N removal by the plant species are also examined (abstract only).

Palazzo, A.J., H.L. McKim and J.M. Graham (1979) Seasonal accumulation of nitrogen, phosphorus and potassium by a forage grass irrigated with wastewater. Proceedings, 71st Annual Meeting, American Society of Agronomy, 5-10 August, Fort Collins, Colorado, p. 35.

The seasonal accumulation of N, P and K in a forage grass is studied to determine the peak nutrient uptake periods during a single growing season. An established sward of Pennlate orchardgrass is used in this experiment and is sprayed weekly with domestic primary wastewater. The grass is harvested three times per season. Treatments include periodic sampling (four times per harvest period) during the growing season (abstract only).

Peters, R.E., C.R. Lee, D.J. Bates and B.E. Reed (1979) Influence of storms on nutrient runoff from an overland flow land treatment system. Presented at the Hydrologic Transport Modeling Symposium, December, New Orleans, Louisiana. St. Joseph, Michigan: American Society of Agricultural Engineers.

This paper presents results from a study of rainfall-runoff relationships and nutrient content of storm water runoff from an overland flow system near Utica, Mississippi. The implications of such runoff relative to the discharge permit are discussed.

Reed, S.C. (1979) Health aspects of land treatment. Presented at the Technology Transfer Seminars, Land Treatment of Municipal Wastewater Effluents. U.S. Environmental Protection Agency and U.S. Army Corps of Engineers.

The health aspects of major concern are N, metals, organics and pathogens. Parasites, crop contamination, runoff, groundwater contamination and aerosols are discussed in relation to pathogens.

1978 ENTRIES

Publications in open literature

Aulenbach, D.B., R.R. Harris and R.C. Reach (1978) Purification of secondary effluent in a natural sand filter. Journal of the Water Pollution Control Federation, vol. 50, p. 86-94.

The Lake George Village Rapid Infiltration Sewage Treatment Plant has been discharging the settled trickling filter effluent onto natural delta sand beds and allowing the sand system to purify the effluent for 37 years. This study determines the quality of the effluent as it passes through the sand bed.

Bausum, H.T., B.E. Brockett, P.W. Schumacher, S.A. Schaub, H.L. McKim and R.E. Bates (1978) Microbiological aerosols from a field source during sprinkler irrigation with wastewater. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 2. CRREL, p. 273-280.

This paper presents measurements of the strength, dispersion, decay and particle size characteristics of bacterial aerosols generated by spray irrigation. This study provides simultaneous source strength and meteorological data adequate for predictive modeling of aerosol plume dispersion.

Belser, L.W. and E.L. Schmidt (1978) Diversity in the ammonia-oxidizing nitrifier population of a soil. Applied and Environmental Microbiology, vol. 36, no. 4, p. 584-588.

Multiple genera of NH_4^+-oxidizing chemoautotrophic nitrifiers in a soil are detected, isolated and studied by means of modified MPN techniques. The soil examined is a silt loam treated with $NH_4^+ + NO_3^-$ or sewage effluent. Three different MPN media are compared for total count and species selectivity. The selectivity and counting efficiency of MPN media are also studied by observing the growth response of representative pure cultures isolated from the soil.

Belser, L.W. and E.L. Schmidt (1978) Serological diversity within a terrestrial ammonia-oxidizing population. Applied and Environmental Microbiology, vol. 36, no. 4, p. 589-593.

Fluorescent antibodies prepared against 16 NH_4^+-oxidizing nitrifying bacteria are examined as to cross reactivity. Isolates obtained from a single soil are stained to examine the effectiveness of the suite of fluorescent antibodies for study of a given NH_4^+-oxidizing population.

Clapp, C.E., A.J. Palazzo, W.E. Larson, G.C. Marten and D.R. Linden (1978) Uptake of nutrients by plants irrigated with municipal wastewater effluent. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 1. CRREL, p. 395-404.

This paper presents comparisons of plant nutrient uptake by corn and forage grasses irrigated with secondary municipal wastewater or treated with inorganic fertilizer. Characteristics of effluent from various locations are given for the plant nutrients as well as for quality indicators. The importance of the presence of varying amounts of N, P and K in effluent is discussed. This paper graphically presents total seasonal N uptake by corn, reed canarygrass and other selected forage grasses. N uptake with time within seasons by reed canarygrass during the normal first cutting period is also illustrated.

Cole, D.W. and P. Schiess (1978) Renovation of wastewater and response of forest ecosystems: the Pack Forest Study. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 1. CRREL, p. 323-331

Wastewater from a secondary treatment facility is applied to seedlings, an established 45-year-old Douglas fir forest, a barren plot and a grass plot. Ion fluxes within the soil and nutrient use by the vegetation are monitored monthly. The efficiencies of these systems in renovating applied wastewater are calculated.

Dowdy, R.H., W.E. Larson, J.M. Titrud and J.J. Latterell (1978) Growth and metal uptake of snap beans grown on sewage sludge amended soil: A four-year field study. Journal of Environmental Quality, vol. 7, p. 252-257.

The long-term trace metal accumulations in edible snap bean tissue are measured over a 4-year period to determine the effect of annual sludge applications on trace metal uptake, and the residual effect on metal uptake by subsequent crops of a single large sludge application.

Dowdy, R.H., G.C. Marten, C.E. Clapp and W.E. Larson (1978) Heavy metals content and mineral nutrition of corn and perennial grasses irrigated with municipal wastewater. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 2. CRREL, p. 175-181.

This paper reports the effect of 4 years of high effluent loading on the trace metal and mineral composition of corn and selected perennial forage grasses. This field study is conducted on a well-drained silt loam soil.

Gaseor, R.A. and L.J. Biever (1978) Use of wastewater in turf irrigation. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 2. CRREL, p. 165-173.

The use of wastewater for turf irrigation is investigated at the U.S. Air Force Academy's Eisenhower Golf Course, which has been irrigated with secondary wastewater since 1960. The soil is sampled at 7.6 cm increments to a depth of 45.7 cm and tested for elevated levels of K, Cu, Fe and Zn. The turf is checked for any changes in species composition and any other adverse effects.

Gupta, S.C., M.J. Shaffer and W.E. Larson (1978) Review of physical-chemical-biological models for a prediction of percolate water quality. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 1. CRREL p. 121-132.

Differences and similarities among various models are pointed out in terms of 1) type of flow, 2) initial and boundary conditions, 3) presence of plant roots, 4) type of salt flow mechanisms, 5) initial condition of salt flow models, and 6) various interactions with soil particles or with other salts in solution. The models can be classified as 1) analytical solutions, 2) numerical solutions, or 3) a combination of analytical and numerical solutions. An illustration of predicted water quality using the Bureau of Reclamation's combination-type model versus measured values from an experiment at Apple Valley, Minnesota, is included.

Ham, G.E. and R.H. Dowdy (1978) Soybean growth as influenced by soil amendments of sewage sludge and heavy metals: Field studies. Agronomy Journal, vol. 70, p. 326-330.

The objectives of this field research are to compare soybean plant growth and metal uptake of salt- and sludge-borne metals and to determine the partitioning of these heavy metals into the various plant parts.

Iskandar, I.K. (1978) The effect of wastewater reuse in cold regions on land treatment systems. Journal of Environmental Quality, vol. 7, p. 361-368.

Six outdoor test cells are used to investigate the effect of land treatment in a cold region on groundwater quality, soils and vegetation. The organic C, BOD, SS, fecal coliform and P levels are determined for the two soils used. The principal mechanisms for N removal are discussed. The movement of applied heavy metals is also monitored.

Iskandar, I.K. (1978) History of land treatment of wastewater. In Proceedings, Land Treatment of Waste Effluent Symposium, 26-28 April, College Park, Maryland. University of Maryland, p. 6-11.

This report summarizes the history of the use of the natural soil-plant system for purifying wastewater. The reasons for the success or failure of these old systems are documented.

Iskandar, I.K. (1978) Overview of existing land treatment systems. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 1. CRREL p. 193-200.

This paper reviews existing systems of land application. Particular emphasis is placed upon the historical philosophy of the use of the natural soil-plant system for purifying wastewater, reasons for the success or failure of the older systems, and experience gained from their design, construction and operation.

Iskandar, I.K. and H.M. Selim (1978) Evaluation of N models for prediction of NO_3-N in percolate water in land treatment. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 1. CRREL, p. 163-169.

This paper reviews existing N models for use with agricultural soils and determines their applicability in land treatment systems. Three processes are considered critical: 1) chemical and biological transformations of N

species, 2) transport of water and soluble N species, 3) plant uptake of water and N species.

Jenkins, T.F. and C.J. Martel (1978) Pilot scale study of overland flow land treatment in cold climates. Journal of Progress in Water Technology, vol. 11, no. 4-5, p. 207-214.

This study is designed to investigate the treatment effectiveness of overland flow over 12 months of continuous use in a cold climate. Primary and secondary wastewaters are applied to an overland flow site. Applied wastewater as well as surface and subsurface flows are monitored for NO_3^-, NH_4^+, TKN, BOD, SS, pH, conductivity and total P.

Jenkins, T.F., C.J. Martel, D.A. Gaskin, D.J. Fisk and H.L. McKim (1978) Performance of overland flow land treatment in cold climates. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 2. CRREL, p. 61-70.

This study evaluates the performance of overland flow systems, especially during the winter months. Primary wastewater, secondary wastewater, and tapwater are applied to a prototype overland flow site. Composite water samples are analyzed for pH, BOD, TOC, SS, NO_3, TKN, NH_4, total P, major cations, fecal coliform, conductivity and Cl.

Latterell, J.J., R.H. Dowdy and W.E. Larson (1978) Correlation of extractable metals and metal uptake of snap beans grown on soil amended with sewage sludge. Journal of Environmental Quality, vol. 7, p. 435-440.

In this field study anaerobically digested sludge was applied to a sandy soil as single applications or as three annual sludge applications. In both cases sludge-borne trace metals removed by several chemical extractants are correlated to trace metal uptake by snap beans and soil organic matter.

Linden, D.R., W.E. Larson and R.E. Larson (1978) Agricultural practices associated with land treatment of domestic wastewater. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 1. CRREL, p. 313-322.

This paper outlines field management practices and how they are used to maximize the nutrient renovation of wastewater when it is recycled through a soil-crop system. Crop selection, soil drainage, methods of irrigation, close-seeded forages and row-crop management are discussed.

Marten, G.C., R.H. Dowdy, W.E. Larson and C.E. Clapp (1978) Feed quality of forages irrigated with municipal sewage effluent. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, Hanover, New Hampshire, vol. 2. CRREL, p. 183-190.

In this study municipal sewage effluent is applied to five persistent perennial forage grasses, corn grown for silage and grain during each of 3 years. The effect of the effluent on digestibility, and protein, Ca and P contents of each crop is discussed.

McKim, H.L. (Coordinator) (1978) State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire. CRREL.

This symposium summarizes the state of knowledge of the practical aspects of land treatment and identifies the suitable approaches for the design of such systems. The topics include: site selection considerations, national and international case studies, health effects, pretreatment considerations, uses of wastewaters in agricultural and forest systems, monitoring, modeling and design criteria. The Proceedings are published in two volumes. Volume I contains the invited papers presented and discussed at the conference; volume II contains shorter papers about on-going research.

McKim, H.L., J.R. Bouzoun, C.J. Martel, A.J. Palazzo and N.W. Urban (1978) Land treatment systems and the environment. Proceedings, American Society of Civil Engineers National Convention, 16-20 October, Chicago, Illinois. New York: ASCE, p. 201-225.

The design and performance of rapid infiltration, slow infiltration and overland flow technology is discussed. The efficiency of N and P removal, factors controlling treatment efficiency and management practices are discussed, as well as the degree of pretreatment necessary.

Merry, C.J. (1978) The use of remote sensing techniques and other information sources in regional site selection of potential land treatment areas. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 1. CRREL, p. 107-120.

This paper demonstrates the use of satellite and aircraft data products in the mapping of regional land use. In addition, available sources for hydrologic, geologic, soils and topographic information are discussed for use in evaluating sites for land treatment potential.

Nakano, Y. (1978) Evaluation of the moving boundary theory in Darcy's flow through porous media. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 1. CRREL, p. 143-151.

Using continuum physics, this paper shows that across both the water table and the wetting front local acceleration generally suffers a non-zero jump, and these two boundaries can be interpreted as acceleration waves. This interpretation is found to be consistent with reported regularity results obtained from a purely mathematical viewpoint.

Nakano, Y. (1978) Theory and numerical analysis of moving boundary problems in the hydrodynamics of porous media. Water Resources Research, vol. 14, no. 1, p. 125-134.

The exact mathematical descriptions of a boundary between unsaturated flow and saturated flow as well as a wetting front are obtained. A new concept for numerical analysis of flow in a partly unsaturated and a partly saturated porous medium is introduced.

Nakano, Y. and I.K. Iskandar (1978) Simulation of the movement of conservative chemicals in soil solution. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 2. CRREL, p. 371-380.

A numerical method is introduced to simulate the movement of conservative chemicals in soil by water. The method is essentially based upon a finite element approximation to the equation of continuity, and each element constitutes a complete mixing cell. The theoretical justification of the method is presented and the accuracy of the method is examined using experimental data obtained from a large lysimeter.

Palazzo, A.J. and H.L. McKim (1978) The growth and nutrient uptake of forage grasses when receiving various application rates of wastewater. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 2. CRREL p. 157-163.

The growth and nutrient removal of forage grasses that received 3 years of wastewater application are reported. The forages received wastewater at various application rates and schedules and grew in either a sandy loam or a silt loam soil. Plant and soil analyses are presented.

Peters, R.E. and C.R. Lee (1978) Field investigations of advanced treatment of municipal wastewater by overland flow. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 2. CRREL, p. 45-50.

Overland flow treatment of municipal facultative lagoon effluent is studied using research plots at Utica, Mississippi. The factors evaluated include the amount of wastewater applied, length of application period, slope of treatment area, crop management and reduction in BOD, SS, N, P, heavy metals and coliforms.

Selim, H.M. and I.K. Iskandar (1978) Nitrogen behavior in land treatment of wastewater: A simplified model. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 1. CRREL, p. 171-179.

A simplified mathematical model is developed that describes transformations and transport of N under transient soil water flow conditions. Kinetic reactions are assumed to govern the nitrification and denitrification processes. A macroscopic approach is used to incorporate plant uptake of water as well as NO_3^--N and NH_4^+-N from the soil solution. The sensitivity of the model to changes in rate of N transformation, N uptake by plants, and schedule and amounts of N application are also investigated. The model can be used as a tool to predict the fate of N in land treatment systems.

Sletten, R.S. (1978) Land application of wastewater in permafrost areas. In Proceedings, Third International Conference on Permafrost, 10-13 July, Edmonton, Alberta, Canada. National Research Council of Canada, p. 911-917.

An experimental study conducted near Fairbanks, Alaska, investigates both high-rate and low-rate systems for polishing aerated lagoon effluent to meet secondary infiltration treatment criteria. The two systems are compared for feasibility in cold climates based on N removal, winter storage needs, vegetative uptake and availability of required soil type.

Spaine, P.A. and C.J. Merry (1978) Computer procedure for comparison of land treatment and conventional treatment: preliminary designs, cost analysis and effluent quality predictions. In State of Knowledge in Land Treatment of Wastewater, Proceedings of an International Symposium, 20-25 August, Hanover, New Hampshire, vol. 2. CRREL, p. 335-340.

During 1972, a manual for the design of wastewater treatment facilities was developed by USAEWES. To complete the manual and to assist the design engineer, the computer model CAPDET was developed. The CAPDET program provides planning level design and cost evaluations for any wastewater treatment system. CAPDET can be used as a planning tool to estimate the costs and designs of land treatment systems and as a screening tool to compare a wide range of alternative designs.

Uiga, A. and R.S. Sletten (1978) An overview of land treatment from case studies of existing systems. Journal of the Water Pollution Control Federation, February, p. 277-285.

The operations of four full-scale land treatment systems are investigated for treatment performance, cost (capital, and operation and maintenance), and soil chemistry changes that may halt application or decrease performance. The four sites are Livermore, California (8 years of

operation), Manteca, California (11 years), Quincy, Washington (20 years), Calumet, Michigan (88 years). Each system is described separately (history and current operations), then compared with the other three sites. CRREL research studies are used to explain observed differences. This paper summarizes the previously reported data and develops a comparative cost analysis for the sites.

Technical reports

Bilello, M.A. and R.E. Bates (1978) Climatic survey at CRREL in association with the land treatment project. CRREL Special Report 78-21 (ADA 062 518).

Six test cells at CRREL are used to study the effect of wastewater application on various types of soil and vegetation. This paper reports basic information about the climate proximate to these test cells and provides summarized results of the collected climatic data. Meteorological considerations for the operation of wastewater treatment systems are presented in reference to the CRREL test program.

Blake, B.J., B.E. Brockett and I.K. Iskandar (1978) Construction and performance of platinum probes for measurements of redox potential. CRREL Special Report 78-27 (ADA 062 426).

A simple method is described for constructing and testing platinum oxidation-reduction probes in the laboratory. The probes are "blacked" with platinum chloride to increase their lifetime. Methods of standardization and problems encountered are discussed.

Edwards, A.P. (1978) A guide to the use of ^{14}N and ^{15}N in environmental research. CRREL Special Report 78-18 (ADA 060 385).

This study uses natural or artificial stable isotopic labeled mineral N to determine the fate of N in wastewater. The possibilities and problems associated with the small amounts of N normally present after secondary waste treatment are assessed. The methods minimize analytical errors and are applicable to other types of environmental research involving isotope ratio analysis as a means of tracing N in the biosphere.

Iskandar, I.K. and Y. Nakano (1978) Soil lysimeters for validating models of wastewater renovation by land application. CRREL Special Report 78-12 (ADA 059 994).

This report describes the construction, operation and performance of large-scale lysimeters. These lysimeters continuously monitor soil moisture flow, soil temperature and redox potential with depth, and sample soil water and soil air with depth. The rate of soil water movement to the groundwater is continuously monitored by a rain gage and a recorder.

The automatic spray system simulates field conditions and is described in this report.

Iskandar, I.K., D. Robinson, W. Willcockson and E. Keefauver (1978) Computer file for existing land application of wastewater systems: A user's guide. CRREL Special Report 78-22 (ADA 062 658).

This computer program, written in BASIC, stores and retrieves information on existing wastewater land treatment systems. This program provides assistance to design engineers during the planning of new land treatment systems by making available the design criteria and performance characteristics of operating systems. The SEARCH program locates systems with specific design parameters, such as flow rate, waste type, application rate and mode, ground cover and length of operation. The printout from SEARCH includes a list of articles on similar systems in addition to the design parameters.

Jenkins, T.F. and S.T. Quarry (1978) Methodology for nitrogen isotope analysis at CRREL. CRREL Special Report 78-8 (ADA 054 939).

This report documents the chronology of events and the procedures employed in developing an N isotope analysis capability at CRREL. Both the instrumental and wet chemistry procedures are reported to enable others interested in the procedures to obtain useful data. The procedures described have resulted in the ability to measure the $^{15}N - {}^{14}N$ ratio to a precision of 0.001 atom %, a value easily within the acceptable range for tracer experiments.

Jenkins, T.F., A.J. Palazzo, P.W. Schumacher, D.B. Keller, J.M. Graham, S.T. Quarry, H.E. Hare, J.J. Bayen and E.S. Foley (1978) Five-year performance of CRREL land treatment test cells. CRREL Special Report 78-26 (ADA 086 172).

The performance of the six land treatment test cells is summarized over a 5-year period from June 1973 through May 1978. The data presented include quality and volume of wastewater applied and percolate resulting from application of primary and secondary wastewater by spray irrigation. Mass loadings and removals are presented as well as crop production and nutrient uptake. Nutrient balance sheets are shown that demonstrate the percentage of N and P that is attributed to crop uptake and leachate over this period.

Nakano, Y. (1978) The mathematical description of a moving boundary problem in an elliptic-parabolic system of partial differential equations in the hydrodynamics of porous media. In Transactions of the 23rd Conference of Army Mathematicians, Hampton, Virginia. Research Triangle Park, North Carolina: Army Research Office, ARO Report 78-1, p. 11-20.

The simultaneous solution of two types of partial differential equations, a parabolic equation for unsaturated flow and an elliptic equation for saturated flow, is required for analysis of water movement in partly unsaturated and partly saturated porous media. A new and complete mathematical description of the boundary is obtained.

Nylund, J.R., R.E. Larson, C.E. Clapp, D.R. Linden and W.E. Larson (1978) Engineering aspects of an experimental system for land renovation of secondary effluent. CRREL Special Report 78-23 (ADA 062 923).

A research system was designed and installed at the Apple Valley Wastewater Treatment Plant in Rosemount, Minnesota, to develop agricultural management practices for removal of N from municipal wastewater effluent.

Palazzo, A.J. (1978) Effects of wastewater sewage sludge on the growth and chemical composition of turfgrasses. CRREL Special Report 78-20 (ADA 061 878).

This greenhouse study determines the effects of wastewater and sewage applications on the growth and chemical composition of two turfgrass mixtures. A mixture of tall fescue and annual ryegrass is compared to a mixture of Kentucky bluegrass, red fescue and annual ryegrass.

Theses

Jacobson, S.N. (1978) Preliminary investigations of the kinetics of nitrogen transformation and nitrosamine formation in land treatment of wastewater. M.S. Thesis, Cornell University, Ithaca, New York.

Laboratory experiments test the effect of soil pH, C source and temperature on denitrification rates in two soils, a silt loam and a sandy loam. The active denitrifiers in the test soils are characterized. Comparisons are made between the NO_3^--N per cell needed for four strains of denitrifiers and the NO_3^--N per cell consumed by the countable numbers of denitrifiers.

Presentations

Edwards, A.P. and I.K. Iskandar (1978) Assumption and errors in the use of ^{15}N as a tracer in N-balance studies. Poster session at 70th Annual Meeting, American Society of Agronomy, 3-8 December, Chicago, Illinois.

Nine major sources of error leading to low values for the percentage or equivalents of applied labeled-N recovered in balance-sheet studies are given (abstract only).

Jenkins, T.F., I.K. Iskandar and S.T. Quarry (1978) ^{15}N as a tracer for nitrogen transformation and transport in land treatment. Proceedings, 70th Annual Meeting, American Society of Agronomy, December 3-8, Chicago, Illinois, p. 27.

This study determines the best procedure for documentation of the transformation and transport of N under wastewater irrigation using an ^{15}N tracer. Four columns, packed with silty loam and covered with grass, are treated with 7.5 cm of water or wastewater weekly. Soil solution at depth and leachate are analyzed weekly for concentration and ^{15}N ratios of NO_3^- and NH_4^+. Four strategies for applying the ^{15}N tracer are tested (abstract only).

Jenkins, T.F. and C.J. Martel (1978) Pilot scale study of overland flow land treatment in cold climates. Presented at the International Conference on Developments in Land Treatment and Utilization, October 23-27, Melbourne, Australia.

For text see Journal of Progress in Water Technology, vol. 11, no. 4-5, p. 207-214.

Leggett, D.C. and I.K. Iskandar (1978) Computer model for nitrification in soils under nitrogen-limiting conditions. Proceedings, 70th Annual Meeting, American Society of Agronomy, 3-8 December, Chicago, Illinois, p. 29.

A Michaelis-Menten-Monod kinetic model is developed to predict nitrification in soils. Application of the model requires the assumption that N is the sole limiting nutrient. A further assumption is that pH dependence can be described in terms of active site dissociation and non-competitive inhibition by nitrous acid and NH_4^+. All rate and Michaelis constants are approximated by values from the literature. Some features of the model and examples of its prediction are compared with experimental data (abstract only).

Marten, G.C., C.E. Clapp and W.E. Larson (1978) Wastewater effluent influence on persistence, quality, and yield of perennial forages and maize. Proceedings, 70th Annual Meeting, American Society of Agronomy, 3-8 December, Chicago, Illinois, p. 23.

The effect of municipal wastewater application on eight perennial forages and maize is examined over a 4-year period. The effect of effluent quantity on persistence and digestibility of each species is determined.

The crude protein and silica contents of each species is examined (abstract only).

McKim, H.L. and I.K. Iskandar (1978) Land treatment of wastewater in the northern United States. Proceedings, 70th Annual Meeting, American Society of Agronomy, 3-8 December, Chicago, Illinois, p. 31.

This 4-year study determines if land treatment is a viable method for treating primary and secondary wastewater. Grass, legumes, forests or row crops are tested as possible vegetative covers. The effect of application rate, irrigation schedule and specific soil information on water quality is discussed (abstract only).

Peters, R.E. and C.R. Lee (1978) The potential of overland flow to treat runoff in the Kissimmee River Valley and Taylor Creek-Nubbin Slough Watersheds. In Presented at the Symposium on Environmental Quality Through Wetlands Utilization, February 28 - March 2, Tallahassee. Florida.

The use of overland flow in the Kissimmee Valley for renovation of dairy lagoon wastes through spray irrigation, and recycling of nutrients for crop production from nonpoint agricultural runoff are discussed.

Peters, R.E., C.R. Lee and F. Hall, Jr. (1978) Nutrient content of stormwater runoff from overland flow land treatment systems. Proceedings, 70th Annual Meeting, American Society of Agronomy, 3-8 December, Chicago, Illinois, p. 33.

Flow activated automatic water samplers are used to sample stormwater runoff from grassed field plots irrigated with domestic sewage lagoon effluent. Several storms of various intensities and durations are sampled and the runoff is analyzed for total N, NH_4, NO_3, total P and ortho-P (abstract only).

Draft translations

Abramov, B.A. and V.I. Korobov (1978) Use of outflow for tree and bush species irrigation. CRREL TL 690 (ADA 055 747).

This paper discusses the results of studies initiated in Volgogradskaya Oblast on the use of industrial wastewater for the irrigation of tree and bush species.

CRREL (1978) Neutralization of organic substances in wastewater by plants, 1975. CRREL TL 676 (ADA 053 435).

This report discusses the neutralization of 21 organic chemicals in treatment plants determined by analyses using a flame ionizing detector (author unknown).

CRREL (1978) Collection of articles on the utilization of animal waste for irrigation. CRREL TL 688 (ADA 055 779).

This collection of papers discusses animal wastewater uses in irrigation. Methods for prevention of contamination of water bodies, assessment of treatment of the outflow from animal husbandry complexes, uses for liquid manure, and effects of irrigation on crops are given in this report (author unknown).

CRREL (1978) Algolization of wastewater with subsequent use for irrigation, 1975. CRREL TL 689 (ADA 069 854).

The use of Biological Oxidation Contact Stabilization (BOCS) ponds to purify wastewater for use in irrigation is discussed in this report (author unknown).

CRREL (1978) Collection of articles on wastewater and its uses for irrigation in the Soviet Union. CRREL TL 692 (ADA 069 857).

This collection of articles covers a wide spectrum of subjects related to the use of wastewater in irrigation. Topics include: soil purification of wastewater, biological oxidation as a pretreatment and optimization of BOCS pond construction, a method for determining the usefulness of irrigation, permissible substance contents of feedcrops, effects on perennial grass yield, effectiveness of supplementation with fertilizers, and health effects on animals raised on irrigated crops.

Dodolina, V.T. (1978) Irrigation use of food industry wastewater, 1976. CRREL TL 675 (ADA 053 434).

This study is conducted by the All-Union Scientific Research Institute for the Agricultural Utilization of Waste Water (VNIISSV). It establishes that the wastewater of starch plants and sugar refineries can be used for irrigation of meadows, pastures and fodder, grain and industrial crops. This wastewater has a high fertilizing value and is chemically characterized in this report.

Dodolina, V.T. (1978) Wastewater classification by fertilizing value. CRREL TL 691 (ADA 055 748).

This report, prepared by VNIISSV, classifies wastewater by its fertilization values. Wastewater from cities, settlements, industrial enterprises and animal husbandry complexes are classified.

Kovaleva, N.A., L.F. Mikheeva and M.I. Demina (1978) Wastewater use for feed crop land, 1976. CRREL TL 673 (ADA 053 432).

This report discusses experiences of various Soviet farms using wastewater irrigation for feed crop land.

Saiapin, V.P. (1978) Nutrition value and fodder harmlessness of plant output grown with textile industry wastewater irrigation, 1976. CRREL TL 671 (ADA 035 225).

This paper discusses the effect of irrigation with wastewater from the textile industry upon fodder crops and animal feeding. The effects on the animals' health, the productivity and nutritive value of their milk and meat, and their capacity for reproduction are discussed.

Shcherbakov, A.S. et al. (1978) Method of wintertime sprinkler distribution of wastewater, 1978. CRREL TL 674 (ADA 053 433).

This paper presents a method for the distribution of wastewater through a sprinkler system in wintertime by reducing the outflow of thawed wastewater from the irrigated lot. This method ensures the even penetration of the thawed water into the soil along the entire irrigated sector.

1977 ENTRIES

Publications in open literature

Baillod, C.R., R.G. Waters, I.K. Iskandar and A. Uiga (1977) Preliminary evaluation of 88 years of rapid infiltration of raw municipal sewage at Calumet, Michigan. In Land as a Waste Management Alternative, Proceedings of the 1976 Cornell Agricultural Waste Management Conference (R.C. Loehr, Ed.). Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc., p. 489-510.

This study investigates the long-term influence of land treatment on the soil-groundwater environment. This article is concerned with a rapid infiltration system that has served the Village of Calumet, Michigan, for the past 88 years and may be the oldest land treatment site currently in use in the U.S.

Clapp, C.E., D.R. Linden, W.E. Larson, G.C. Marten and J.R. Nylund (1977) Nitrogen removal from municipal wastewater effluent by a crop irrigation system. In Land as a Waste Management Alternative, Proceedings of the 1976 Cornell Agricultural Waste Management Conference (R.C. Loehr, Ed.). Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc., p. 139-150.

The objective of this study is to develop agronomic practices for maximum N use by crops irrigated with municipal wastewater. The N in the soil-water-crop system is accounted for by measuring the characteristic components in the field experiment.

Dowdy, R.H. and G.E. Ham (1977) Soybean growth and elemental content as influenced by soil amendments of sewage sludge and heavy metals: Seedling studies. Agronomy Journal, vol. 69, p. 300-304.

Many research studies substitute soluble metal salts for sludge-borne metals in attempts to define heavy metal uptake by plants. Soybean uptake of sludge and salt-borne heavy metals is measured to assess this experimental approach and determine the effect of sewage sludge on the availability of soluble metals.

Gupta, S.C., R.H. Dowdy and W.E. Larson (1977) Hydraulic and thermal properties of a sandy soil as influenced by incorporation of sewage sludge. Soil Science Society of America Journal, vol. 41, p. 601-605.

The effects of sewage sludge additions on hydraulic and thermal properties of sandy soil are studied. The soil-water retention, hydraulic conductivity, soil-water diffusivity, soil temperature and heat capacity for the treated and untreated soils are compared.

Hunt, P.G., C.R. Lee and R.E. Peters (1977) Update: overland flow. Water Spectrum, vol. 9, no. 2, p. 23-29.

This paper presents a general discussion of the reseach needs for overland flow technology. Topics that are discussed include: P removal and the long-term effect of aluminum sulfate treatment, heavy metal removal, pathogen transmission, quality of runoff during rainfall and effect of plant composition.

Iskandar, I.K., R.S. Sletten, T.F. Jenkins and D.C. Leggett (1977) Wastewater treatment alternative needed. Water and Wastes Engineering, vol. 14, no. 11, p. 82-87.

Wastewater application rate, effect of preapplication treatment, soil type and seasonal effects are considered in this study by use of prototype test cells.

Larson, W.E. and G.E. Schuman (1977) Problems and need for high utilization rates of wastes. In Proceedings, Symposium on Soils and Management of Organic Wastes and Waste Waters, Madison, Wisconsin, chap. 23. Soil Science Society of America, p. 587-604.

This chapter describes situations where large amounts of organic wastes and wastewaters can be used successfully without environmental deterioration and discusses some of the requirements for site selection, necessary properties of the waste and management of the area.

Murrmann, R.P. and I.K. Iskandar (1977) Land treatment of wastewater: Case studies of existing disposal systems at Quincy, Washington, and Manteca, California. In Land as a Waste Management Alternative, Proceedings of the 1976 Cornell Agricultural Waste Management Conference (R.C. Loehr, Ed.). Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc., p. 467-488.

This paper discusses the findings obtained for two slow infiltration sites located at Manteca, California, and Quincy, Washington.

Palazzo, A.J. (1977) Land application of wastewater: Forage growth and utilization of applied nitrogen, phosphorus and potassium. In Land as a Waste Management Alternative, Proceedings of the 1976 Cornell Agricultural Waste Management Conference (R.C. Loehr, Ed.). Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc., p. 171-180.

This 2-year study characterizes the effectiveness of a forage mixture in renovating wastewater when the waste is applied to land at several rates. Nutritional changes through soil and plant analysis are determined to permit correction, where necessary, through proper management procedures.

Sletten, R.S. and A. Uiga (1977) Feasibility study of land treatment at a subarctic Alaskan location. In Land as a Waste Management Alternative, Proceedings of the 1976 Cornell Agricultural Waste Management Conference (R.C. Loehr, Ed.). Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc., p. 533-547.

This paper discusses the feasibility of land application in artic and subartic Alaska so that EPA secondary effluent standards may be met. This investigation is conducted at Eielson Air Force Base during the summers of 1974 and 1975.

Uiga, A., I.K. Iskandar and H.L. McKim (1977) Water reuse at Livermore, California. In Land as a Waste Management Alternative, Proceedings of the 1976 Cornell Agricultural Waste Management Conference (R.C. Loehr, Ed.). Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc., p. 511-531.

This study compares multiple reuse practices for treated wastewater effluent, and evaluates short-term (annual) and long-term (8 years) effects of the wastewater reuse options.

Technical reports

Bouzoun, J.R. (1977) Land treatment of wastewater at West Dover, Vermont. CRREL Special Report 77-33 (ADA 046 300).

A general description of a wastewater land treatment system located in a "cold" climatic region is given. Secondary wastewater is sprayed on a forested knoll. The system is operated during the winter when the ambient air temperature is as low as 10°F (-12.2°C). Spray nozzles have been developed that ensure rapid drainage of the spray laterals after each spray cycle and, therefore, prevent freezing.

Iskandar, I.K., R.P. Murrmann and D.C. Leggett (1977) Evaluation of existing systems for land treatment of wastewater at Manteca, California, and Quincy, Washington. CRREL Report 77-24 (ADA 045 357).

Wastewater treatment sites at Manteca, California, and Quincy, Washington, are evaluated for their performance and long-term impact. These sites have been operated as slow-infiltration systems for up to 20 years. Performance is evaluated in terms of water quality, while soil chemical parameters are measured to determine the effects of prolonged wastewater application at the sites.

Johnson, D.W. and D.W. Cole (1977) Anion mobility in soils: Relevance to nutrient transport from terrestrial to aquatic ecosystems. Ecological Research Series, EPA 600 3-77-068 (distributed by NTIS as no. PB-271 725).

This report reviews the current knowledge of soil anion adsorption reactions and their effects on leaching, and suggests a simple model, based on anion production and adsorption considerations, to predict and explain nutrient transport. The relationship of this approach to that based on cation production and adsorption is discussed.

Linden, D.R. (1977) Design, installation, and use of porous ceramic samplers for monitoring soil water quality. USDA Technical Bulletin 1562.

This report describes how to use porous ceramic samplers, how to construct a soil-water sampling system, how and where to install samplers, and how to obtain samples. It is intended as a guide for users of porous ceramic samplers who have little or no background knowledge of soil, hydrology or geology.

Palazzo, A.J. (1977) Reclamation of acidic dredge soils with sewage sludge and lime at the Chesapeake and Delaware Canal. CRREL Special Report 77-19 (ADA 041 636).

This field study assesses the effects of sewage sludge and lime on the revegetation and reclamation of acidic and infertile dredge soils.

Presentations

Clapp, C.E., D.B. White and M.H. Smithberg (1977) Yields and composition of turf grasses fertilized with sewage sludge. Proceedings, 69th Annual Meeting, American Society of Agronomy, 13-18 November, Los Angeles, California, p. 110.

Liquid and dried anaerobically digested sewage sludge is applied to field plots of Kentucky bluegrass and creeping bentgrass and cropped over two growing seasons. Four N application rates as liquid sludge and two rates as dried sludge are compared with an NH_4-NO_3 control. The dry matter yields, N, P, K and heavy metal contents of each species are compared between sludge treatments and season (abstract only).

Cole, D.W. (1977) Ecosystem research in the natural managed forest: application of wastewaters and dewatered sludges to forest ecosystems. Presented at IUFRO Division I Meeting, September, Ossiach, Austria.

This paper examines the problems that can arise from tending managed forests in light of information derived from studies of forest ecosystems in the Pacific Northwest of the U.S. Of particular concern is the use of a forest as a site for disposal of municiple wastewaters and sludges.

Dowdy, R.H., C.E. Clapp and W.E. Larson (1977) The effect of wastewater treatment on sludge-borne metal accumulation in corn leaf and grain tissue. Proceedings, 69th Annual Meeting, American Society of Agronomy, 13-18 November, Los Angeles, California, p. 24.

This 4-year study assesses the plant availability of tracer metals from sewage sludge. The sewage sludge is applied annually at three rates for the highest treatments of waste-activated, anaerobic and aerobic treated material. Leaf and grain Zn and Cd levels are compared. Tissue Cu, Pb, Cr and Ni levels are also determined (abstract only).

Leggett, D.C. and I.K. Iskandar (1977) Mathematical modeling of nitrification in land treatment of wastewater. Proceedings, 69th Annual Meeting, American Society of Agronomy, 13-18 November, Los Angeles, California, p. 30.

A mechanistic model of nitrification is presented that is based on Michaelis-Menten kinetics. It initially considers soil temperature, pH and concentration of added NH_4^+. The pH dependency is expressed in terms of empirical proton dissociation constants on the active site of the enzyme. The temperature dependance is based on literature data for the

Arrhenius law effect on both the maximum velocity and Michaelis constants. Estimates of population size and specific rates per microorganism are taken from the literature and used to test the model's general validity (abstract only).

Linden, D.R., C.E. Clapp, G.C. Marten and W.E. Larson (1977) Nutrient balance in corn and forage systems fertilized with municipal wastewater effluent. Proceedings, 69th Annual Meeting, American Society of Agronomy, 13-18 November, Los Angeles, California, p. 30.

The removal of N by the forage crops and retention of P and K in the soil rooting zone, and the subsequent levels of N, P and K in the leachate are discussed (abstract only).

McKim, H.L. (1977) Corps of Engineers land treatment program--An overview of four years' research accomplishments. Presented at the 8th Annual Symposium on Military Applications of Environmental Research and Engineering, 7-8 December, Edgewood, Maryland.

This paper addresses the objectives of the land treatment program: evaluating preapplication requirements, optimizing the renovation capacity of land treatment systems, monitoring groundwater quality, and constructing and validating a mathematical model to predict the quality of percolate water from treatment systems.

McKim, H.L. and I.K. Iskandar (1977) Corps of Engineers Land Treatment Program--An overview of four years' research accomplishments. Proceedings, 69th Annual Meeting, American Society of Agronomy, 13-18 November, Los Angeles, California, p. 31.

This paper addresses the objectives of the land treatment program: evaluating preapplication requirements, optimizing the renovation capacity of land treatment systems, monitoring groundwater quality, and constructing and validating a mathematical model to predict the quality of percolate water from treatment systems (abstract only).

Merry, C.J. and P.A. Spaine (1977) The land treatment module of the CAPDET program. Presented at the 8th Annual Symposium on Military Applications of Environmental Research and Engineering, 7-8 December, Edgewood, Maryland.

The computer model CAPDET is developed to complement the Process Design Manual for Land Treatment of Municipal Wastewater and to assist the field engineer. The CAPDET program provides planning level design and cost evaluations of any wastewater treatment system.

Palazzo, A.J. and H.L. McKim (1977) The chemical analysis of forage grasses receiving four years of wastewater applications. Proceedings, 69th Annual Meeting, American Society of Agronomy, 13-18 November, Los Angeles, California, p. 33.

The effect of 4 years of wastewater application on forage crops and their soils is examined. Six outdoor test cells containing sandy loam or silty loam are used. The plant and soil levels of N, P and K are examined. Supplemental greenhouse studies are performed to determine the effect of P and K fertilizers on plant yield (abstract only).

Peters, R.E. and C.R. Lee (1977) Field investigations on overland flow for advanced treatment of municipal wastewater. Proceedings, 69th Annual Meeting, American Society of Agronomy, 13-18 November Los Angeles, California, p. 34.

Land treatment of wastewater by overland flow is studied at a field installation with use of facultative lagoon effluent. Reductions of applied N and P, BOD, SS and fecal coliforms are determined. The effect of aluminum sulfate on P removal is also determined (abstract only).

Draft translations

Wierzbicki, J. (1977) Effect of geography on the extensive agricultural use of sewage, 1950. CRREL TL 642 (ADA 044 765).

This article considers the causes for the elimination of many irrigated fields in England. The importance of climate and soil is discussed.

Wierzbicki, J. (1977) Sewage farming at Ostrow Wielkopolski, 1949. CRREL TL 643 (ADA 044 746).

The sewage from Ostrow Wielkopolski has been purified since 1911 by agricultural use on irrigated fields. This report discusses the method of sewage purification used.

Wierzbicki, J. (1977) Disadvantages and advantages of sewage disposal in connection with agricultural utilization, 1949. CRREL TL 645 (ADA 044 767).

This report details some of the disadvantages and advantages of sewage disposal by agricultural utilization.

Wierzbicki, J. (1977) Supplying water table intake through agricultural use of urban sewage, 1957. CRREL TL 652 (ADA 046 304).

This work presents two basic advantages of agricultural use of urban sewage: the levels of the water table and surface waters in the vicinity of the waterworks intakes rose considerably, and largely fallow land was transformed into fruitful meadows, pastures and arable land.

Wierzbicki, J. (1977) Irrigated fields for urban sewage, 1952. CRREL TL 653 (ADA 046 305).

This report discusses the advantages of using a gravity flow system for transporting wastewater. Cost comparisons are given. Also the effects of irrigation on soils and crop yield are discussed.

1976 ENTRIES

Publications in open literature

Dowdy, R.H., R.E. Larson and E. Epstein (1976) Sewage sludge and effluent use in agriculture. In Land Application of Waste Materials. Ankeny, Iowa: Soil Conservation Society of America, p. 138-153.

This paper suggests guidelines for sludge application on crop land with minimal site monitoring or environmental degradation. This discussion covers potential hazzards, problems and possible solutions, and agricultural benefits. The parameters used for the guidelines include: site selection, N, metals and pathogens. The degree of monitoring required is also discussed.

Hunt, P.G. and C.R. Lee (1976) Land treatment of wastewater by overland flow for improved water quality. In Biological Control of Water Pollution (J. Tourbier and R.W. Pierson, Jr., Eds.). University of Pennsylvania Press, p. 151-160.

This paper presents an overview of land treatment of wastewater, a development of the overland flow system of treatment, and possible modifications of current concepts of overland flow treatment for improved water quality.

Iskandar, I.K. and D.C. Leggett (1976) Reclamation of wastewater by application on land. In Proceedings, Army Science Conference, June 22-25, Research Triangle Park, North Carolina. Army Research Office, p. 199-213.

This paper discusses the results of 2 years of operation of prototype slow-infiltration land treatment systems. Information derived from this work can provide guidance to Corps of Engineers Division and District sanitary engineers on design, operation and management of land treatment systems.

Larson, W.E. and J.R. Gilley (1976) Soil-climate-crop considerations for recycling organic wastes. In Transactions of the ASAE, American Society of Agricultural Engineers, vol. 19, no. 1, p. 85-89,96.

This paper discusses land application of sewage sludges and effluent by considering waste, soil, crop and climatic factors. Soil physical considerations include: hydraulic properties, surface seals, topography and saturation of the soil profile. Soil chemical and biological considerations include: chemical properties of soil, chemical adsorption by soil, effects of Na, K, P on soil exchange, N transformations and NO_3^- leaching, and toxic chemicals and metals in the applicant. The effects of temperature and crop cover are also discussed.

Uiga, A. (1976) Let's consider land treatment, not land disposal. Civil Engineering, American Society of Civil Engineers, vol. 46, no. 3, p. 60-62.

This paper considers land treatment of wastewater as an alternative to land disposal. Pretreatment and disinfection requirements, groundwater and surface water degradation, application rates, hydraulic considerations and economic considerations for land treatment are discussed.

Technical Reports

Iskandar, I.K., R.S. Sletten, D.C. Leggett and T.F. Jenkins (1976) Wastewater renovation by a prototype slow infiltration land treatment system. CRREL Report 76-19 (ADA 029 744).

The feasibility of a slow-infiltration land treatment system as an alternative to advanced waste treatment is studied using six outdoor test cells. Wastewater is applied to forage grasses by spray irrigation. The parameters studied are wastewater application rate, effect of pretreatment, and soil type and seasonal effects on the treatment system.

Lee, C.R., P.G. Hunt, R.E. Hoeppel, C.A. Carlson, T.B. Delaney, Jr. and R.N. Gordon, Sr. (1976) Highlights of research on overland flow for advanced treatment of wastewater. USAEWES Miscellaneous Report Y-76-6 (ADA 033 864).

Greenhouse grass-soil models are used to study overland flow treatment of municipal wastewater. The response of overland flow treatment of N, P and heavy metals to various operating conditions is determined.

Palazzo, A.J. (1976) The effects of wastewater application on the growth and chemical composition of forages. CRREL Report 76-39 (ADA 032 774).

The data presented in this report are related to the capabilities of vegetation in renovating wastewater. Also included are results that reflect on the management of a system for sustained plant performance and N removal.

Satterwhite, M.B., B.J. Condike and G.L. Stewart (1976) Treatment of primary sewage effluent by rapid infiltration. CRREL Report 76-49 (ADA 035 390).

The effectiveness of inundation of a rapid infiltration basin for 7 days followed by a 14 day recovery period is compared with secondary and tertiary treatment in this study.

Satterwhite, M.B., G.L. Stewart, B.J. Condike and E. Vlach (1976) Rapid infiltration of primary sewage effluent at Fort Devens, Massachusetts. CRREL Report 76-48 (ADA 035 730).

This study compares the water quality of unchlorinated primary effluent that has undergone rapid infiltration land treatment with the quality of wastewater that has undergone conventional tertiary treatment. This study is performed at Fort Devens, Massachusetts, and tests the effectiveness of rapid infiltration in a northern environment.

Presentations

Murrmann, R.P. and I.K. Iskandar (1976) Land treatment of wastewater: Case studies of existing disposal systems at Quincy, Washington, and Manteca, California. Presented at the 8th Annual Waste Management Conference, April 28-30, Rochester, New York.

Evaluation of these two systems is presented. Factors considered include site history, operational characteristics, current performance and impact on soil characteristics. At both sites a control field and two disposal fields are compared. Soil samples are analyzed for 30 chemical parameters. Soil solution samples collected at 80- and 160-cm depths, pretreatment water samples, and peripheral drainage water and groundwater samples are analyzed for pH, NH_4^+, NO_3^- and ortho-P.

Nakano, Y. and I.K. Iskandar (1976) Validation of mathematical models of land treatment of wastewater via slow infiltration. Proceedings, 68th Annual Meeting, American Society of Agronomy, 28 November - 3 December. Houston, Texas, p. 29.

The objective of this study is to experimentally validate a mathematical model simulating bio-physical processes in the land treatment of wastewater by slow infiltration. This presentation summarizes the results of investigations in soil water movement and dispersion of Cl in the soil,

and a preliminary study on nitrification and Eh measurements. Experimental data obtained from lysimeters and supplemented by data from test plots are used to evaluate the accuracy of the model simulations (abstract only).

Palazzo, A.J. (1976) Land application of wastewater: Forage growth and utilization of applied N, P, and K. Presented at the 8th Annual Waste Management Conference, April 28-30, Rochester, New York.

The contribution of a forage mixture in the renovation of wastewater by a prototype slow infiltration system is studied. The forage is grown in three outdoor cells containing a sandy loam soil. The forages received domestic wastewater at three rates. Crop yields, soils and tissue analyses, plant removal efficiency and the total uptake of N and P are examined for their relation to the rate of wastewater applied.

Peters, R.E., P.G. Hunt and C.R. Lee (1976) Overland flow treatment of municipal facultative lagoon wastewater. Proceedings, 68th Annual Meeting, American Society of Agronomy, 28 November - 3 December, Houston, Texas, p. 30.

This field test evaluates the advanced treatment of municipal wastewater from a facultative lagoon by overland flow. Various slopes are tested. The extent of N, P, fecal coliform and fecal streptococci removal is determined. The effect of aluminum sulfate is also considered with respect to P removal.

Sletten, R.S. and A. Uiga (1976) Feasibility study of land treatment of wastewater at a subarctic Alaskan location. Presented at the 8th Annual Waste Management Conference, April 28-30, Rochester, New York.

The feasibility of land treatment to meet 1977 secondary treatment standards at Eielson Air Force Base near Fairbanks, Alaska, is discussed. Three test plots, 25 ft square, are sprayed with aerated lagoon effluent at three different rates. Weekly water quality samples are taken from the applied lagoon effluent, from catchment lysimeters at a depth of 6 in., and from well points 4.5 ft deep. Weather and soil data are also collected.

1975 ENTRIES

Publications in open literature

Dowdy, R.H. and W.E. Larson (1975) Metal uptake by barley seedlings grown on soils amended with sludge. Journal of Environmental Quality, vol. 4, p. 229-233.

The removal of metals by 30-day-old barley seedlings from two soils having pHs of 5.9 and 7.9 is studied following the application of sewage sludge. One set of soil-sludge samples was incubated for 1 year before cropping to study the effect of sludge degradation on metal availability.

Dowdy, R.H. and W.E. Larson (1975) The availability of sludge-borne metals to various vegetable crops. Journal of Environmental Quality, vol. 4, p. 278-282.

The uptake of metals by seven vegetable crops is studied after sewage sludge is applied to a coarse sandy soil. The metal contents of the vegetative, fruiting, root and tuber tissues are determined.

Iskandar, I.K. (1975) Urban waste as a source of heavy metals in land treatment. In Proceedings, International Conference on Heavy Metals in the Environment, 27-32 October, Toronto, Ontario, Canada. Ottawa: National Research Council of Canada, p. 417-432.

Heavy metal accumulation in soils and forages of a slow infiltration land treatment system during a 2-year period is discussed. Uptake of heavy metals by plants and soils is compared with the amounts applied, soil type and mode of wastewater application.

Larson, W.E., J.R. Gilley and D.R. Linden (1975) Consequences of waste disposal on land. Journal of Soil and Water Conservation, vol. 30, p. 68-71.

This paper discusses benefits of land disposal, compositition of the wastes, precautions to prevent N-overloading, proper handling of heavy metals and toxic chemicals, and movement of runoff waters.

Technical reports

Schaub, S.A., E.P. Meier, J.R. Kolmer and C.A. Sorber (1975) Land application of wastewater: The fate of viruses, bacteria and heavy metals at a rapid infiltration site. U.S. Army Biomedical Research and Development Laboratory Technical Report 7504 (ADA 011 263).

Rapid infiltration treatment of wastewater is studied to determine if significant quantities of specific microbiological and chemical wastewater constituents could percolate into groundwater. The site selected for study has been in operation for over 30 years. Primary sewage effluent is used for rapid infiltration-percolation.

U.S. Army Corps of Engineers (1975) Status report: Corps of Engineers wastewater management via land treatment research program, July 1974 - January 1975.

This report summarizes the the Corps of Engineers research program on land treatment and related topics. The program includes projects sponsored by both the Civil Works and Military Construction Directorates.

Theses

Archer, S.L. (1975) Characterization of the effluent from a metropolitan Seattle, Washington, treatment facility. M.S. Thesis, University of Washington, Seattle.

This thesis characterizes the organic constituents of the Seattle metropolitan wastewater treatment facility and uses this information to formulate a model.

Presentations

Clapp, C.E., W.E. Larson and M.M. DuBois (1975) Soil carbon and nitrogen changes after field application of sewage sludge. Proceedings, 67th Annual Meeting, American Society of Agronomy, 24-30 August, Knoxville, Tennessee, p. 131.

In this 4-year study, aerobic, anaerobic and waste activated sludges are applied at three rates with fertilized and unfertilized controls. Soil C and N levels and decomposition rates for the sludges are compared for each treatment (abstract only).

Hunt, P.G., C.R. Lee and R.E. Hoeppel (1975) Removal of nitrogen, phosphorus, and trace elements by overland flow treatments of wastewater. Proceedings, 67th Annual Meeting, American Society of Agronomy, 24-30 August, Knoxville, Tennessee, p. 27.

The removal of N, P and heavy metals (Zn, Cu, Mn, Pb, Ni and Cd) from secondary wastewater by overland flow is tested over a 3-year period using greenhouse models. Differing application rates are used. The effect of aluminum sulfate on P removal is also examined (abstract only).

Iskandar, I.K. and H.L. McKim (1975) The effect(s) of two years of wastewater application on soil characteristics. Proceedings, 67th Annual Meeting, American Society of Agronomy, 24-30 August, Knoxville, Tennessee, p. 27.

The effects of application of domestic wastewater enriched with heavy metals to sandy loam and silty loam soils in six test cells over 1 year are examined. The wastewater is enriched with Cu, Zn, Cd, Pb, Hg, Ni and Cr to simulate industrial wastewater. The heavy metal, P, organic C and free iron oxide contents and CEC are determined throughout the soil profile (abstract only).

Leggett, D.C., I.K. Iskandar, T.F. Jenkins and H.L. McKim (1975) Seasonal variation in water quality from a controlled slow infiltration treatment system. Proceedings, 67th Annual Meeting, American Society of Agronomy, 24-30 August, Knoxville, Tennessee, p. 28.

The ability of six outdoor test cells containing silty or sandy loam soils to renovate primary and secondary sewage effluents is discussed. Water quality parameters (nutrients, BOD, SS, heavy metals, coliform bacteria, pH, electrical conductivity and Cl) are monitored at 6-, 18- and 60-in. depths, daily to weekly. The importance of seasonal effects is also considered (abstract only).

Palazzo, A.J., R.S. Sletten and H.L. McKim (1975) The effects of wastewater disinfection on crop yields and tissue analysis of four forage grasses. Proceedings, 67th Annual Meeting, American Society of Agronomy, 24-30 August, Knoxville, Tennessee, p. 30.

This greenhouse study assesses the effects of wastewater disinfection on the yield and chemical composition of four forage grasses--orchardgrass, lincoln smooth bromegrass, reed canarygrass and climax timothy--grown in either sandy loam or silty loam soil. The N, P, K and heavy metal content of the grasses are compared (abstract only).

Uiga, A., M.A. Bilello and A.J. Palazzo (1975) The effects of wastewater management on the water budget of a land treatment system. Proceedings, 67th Annual Meeting, American Society of Agronomy, 24-30 August, Knoxville, Tennessee, p. 35.

A water budget is measured in situ for three test cells containing a sandy loam soil and planted forages. The amount of the daily application and the number of daily applications are varied to determine their effect on the water budget. On-site weather observations include continuous monitoring of precipitation, air and soil temperature, pan evaporation, and several other parameters. Water loss as evapotranspiration and change in soil water are calculated by measuring the amounts of water applied, rainfall, and the amounts of water percolated (abstract only).

Draft translations

Dodolina, V.T. (1975) Sugar plant wastewater suitable for irrigation, 1974. CRREL TL 501 (ADA 017 305).

This report presents information on the suitability of wastewater from a sugar plant for irrigation by studying soil, climate, hydrogeology and the composition of the wastewater. The effects on productivity and water quality are examined.

Dodolina, V.T., V.M. Novikov and A.A. Sollogub (1975) Sugar plant wastewater utilized for irrigation. CRREL TL 500 (ADA 017 306).

This paper discusses the use of sugar plant wastewater for irrigation of agricultural crops. Soil types, water quality of the filtered and unfiltered wastewater, and crop yields are discussed.

Dolivo-Dobrovol'skii, L.B., L.A. Kul'skii and V.F. Nakorchevskaia (1975) Chemistry and microbiology of water, 1971. CRREL TL 506 (ADA 027 708).

This report discusses the chemical and microbiological characteristics of natural and sewage waters, and the chemical and microbiological processes that take place during their purification. Particular attention is devoted to problems of chemical and biological purification, intensification of the methods of treating natural and sewage waters, new reagents and improvement of the treatment method.

L'vovich, A.I. (1975) Natural methods of purifying wastewaters and utilizing them in agriculture: Bibliography, parts 1 and 2, 1971. CRREL TL 505 (ADA 019 105).

This bibliography gives a list of published Soviet material on agricultural use of wastewater and natural methods of purifying it on agricultural and municipal irrigation fields. Material on self-purification of the soil and sanitary and hygenic evaluations of soil methods are presented.

Novikov, V.M. (Ed.) (1975) Natural methods of purifying sewage and its utilization in agricultural management, 1972. CRREL TL 488 (ADA 014 971).

This collection of articles discusses the theoretical and practical aspects of the agricultural use of sewage. The results of research on irrigation with sewage in various types of soil and the effects of sewage on the yield and quality of fodder crops are presented. The suitability of various kinds of sewage for irrigation is evaluated.

Novikov, V.M. (Ed.) (1975) Natural purification of sewage and the economic effectiveness of its utilization for irrigation: A collection of articles, 1975. CRREL TL 491 (ADA 055 636L).

This collection discusses effective use of sewage in agriculture. The report is divided into three sections: irrigation by wastewater, the sanitary-hygenic aspects of irrigated fields, and the economic effectiveness of this process.

Novikov, V.M. (Ed.) (1975) Use of sewage in agriculture, 1969. CRREL TL 499 (ADA 017 303).

This collection of articles, prepared by the Central Scientific Research Station for the Agricultural Utilization of Sewage (TsNISSV), covers existing achievements in the use of sewage for irrigation and the prospects of its development.

1974 ENTRIES

Publications in open literature

Hunt, P.G. and C.R. Lee (1974) Overland flow treatment of wastewater--a feasible approach. In Land Application of Wastewater, Proceedings of a Research Symposium, November 20-21. EPA 903 9-75-017 (NTIS PB-241 438), p. 71-85.

This paper presents an overview of system operation and theory of a limited number of overland flow systems and the research models that respond as predicted by theory for overland flow treatment.

Larson, W.E. (1974) Cities' waste may be soils' treasure. Crops and Soils, vol. 27, p. 9-11.

This paper discusses the use of sludge for fertilizer. The nutrient content of sludge, crop response to sludge, drawbacks and methods of application are discussed.

Larson, W.E., J.R. Gilley and D.R. Linden (1974) Consequences of waste disposal on land. In Land Use: Persuasion or Regulation? Proceedings, 29th Annual Meeting, Soil Conservation Society of America, Syracuse, New York, p. 127-132.

This work is primarily concerned with the potential for use of plant nutrients in wastes on land and some of the precautions needed for successful management.

Technical Reports

Carlson, C.A., P.G. Hunt and T.B. Delaney, Jr. (1974) Overland flow wastewater. USAEWES Miscellaneous Paper Y-74-3 (ADA 008 371).

This study determines the mechanisms involved in wastewater treatment by overland flow so that operational feasibility, design and performance criteria can be more accurately evaluated.

Hoeppel, R.E., P.G. Hunt and T.B. Delaney, Jr. (1974) Wastewater treatment on soils of low permeability. USAEWES Miscellaneous Paper Y-74-2 (ADA 008 370).

This study consists of two experiments. In the first, a clay-soil-reed-canarygrass system is used to study nitrification and denitrification in overland flow; it represents a small-scale simulation of a cannery wastewater disposal system. The second examines the effects of adding sewage sludge to the upper few centimeters of an overland flow system. The levels of N, P, K, Na, Ca, Mg, Cd, Cu, Mn, Pb, Zn and N are examined.

Jellinek, H.H.G. (1974) Soil organics. I. Complexation of heavy metals. II. Bound water. CRREL Special Report 212 (ADA 008 868).

Humic substances (e.g. fulvic and humic acids) are discussed. Complexation of these acids with heavy metal ions is emphasized and the fundamental background of multiple equilibria is presented. Ion exchange and titrate methods are considered with respect to their use for the determination of complex stability constants. The relative importance of organic and inorganic matter in soils is emphasized. The composition of wastewaters with a view to their purification by soil irrigation is indicated. The role of organic matter with respect to water retention is discussed.

Presentations

Hoeppel, R.E., P.G. Hunt and T.B. Delaney, Jr. (1974) Nitrogen removal from wastewater by overland flow mode of land treatment. Proceedings, 66th Annual Meeting, American Society of Agronomy, 10-15 November, Chicago, Illinois, p. 29.

The removal of NH_4^+ and NO_3^- from wastewater is tested in a simulated overland flow system. Greenhouse models containing a mixture of grasses are used. The effect of rate and period of application are examined. The yield of grass and the N gradient is observed down the length of the model (abstract only).

Larson, W.E. and J.R. Gilley (1974) Soil and crop considerations for recycling wastes. Presented at 1974 Winter Meeting of the American Society of Agricultural Engineers, December 10-13. St Joseph, Michigan: ASAE.

The hydraulic and chemical properties of soil are considered important in the design of waste recycling systems. Crop considerations include yield potential, amount of nutrients and elements taken up by a crop, and adaptability of the crop to conditions imposed by the waste, such as insects and diseases.

Lee, C.R., C.A. Carlson and P.G. Hunt (1974) Wastewater phosphorus and heavy metal retention by overland flow land treatment systems. Proceedings, 66th Annual Meeting, American Society of Agronomy, 10-15 November, Chicago, Illinois, p. 31.

The advanced treatment of municipal wastewater by overland flow is monitored with greenhouse models, each containing mixture of grasses. Wastewater is applied at varying hydraulic loading rates. The efficiency of removal of P, Cd, Ni, Cu, Pb and Mn is discussed (abstract only).

McKim, H.L., T.D. Buzzell, R.P. Murrmann, S.C. Reed and W. Rickard (1974) Use of land treatment in wastewater management. Proceedings, 66th Annual Meeting, American Society of Agronomy, 10-15 November, Chicago, Illinois, p. 34.

This long-term research program was initiated in 1973 to develop management practices for economical renovation of municipal wastewater by application to land. An experimental facility is used that includes six prototypes containing sandy loam or silty loam seeded with a grass mixture. Volumes and chemical quality of wastewater and percolate water are monitored. Physical and chemical analyses of soils as well as plant production and nutrient uptake are also evaluated (abstract only).

1973 ENTRIES

Publication in open literature

Hunt, P.G. (1973) Overland flow. Water Spectrum, vol. 5, no. 4, p. 16-21.

This paper answers some of the questions a municipality might have concerning overland flow treatment of wastewater. The concept of wetland agriculture in conjunction with overland flow treatment is also discussed.

Larson, W.E., C.E. Clapp and R.H. Dowdy (1973) Research efforts and needs in using sewage wastes on land. Proceedings, 28th Annual Meeting, Soil Conservation Society of America, 30 September to 3 October, Hot

Springs, Arkansas. Ankeny, Iowa: Soil Conservation Society of America, p. 142-147.

This paper discusses the N, P and trace metal contents of sewage sludge and effluent, field application of sewage wastes, the spread of diseases, soil and crop management, and surface water control systems.

Reed, S.C. and T.D. Buzzell (1973) A sewage treatment concept for permafrost areas. In Permafrost: The North American Contribution to the Second International Conference. Washington, D.C.: National Academy of Sciences, p. 706-712.

A sewage treatment concept developed by CRREL is described. It is compatible with the permafrost environment and offers a substantial savings in construction costs. The concept adopts the passive approach to construction in permafrost by protecting the supporting material from thermal stress.

Presentations

Reed, S.C. (1973) Land disposal of wastewaters: State-of-the-art. Presented at the National Symposium on Ultimate Disposal of Wastewaters and their Residuals, 26-27 April 1973, Durham, North Carolina.

This paper represents a brief summary of the comprehensive report issued and still available, CRREL Special Report 171, Wastewater Management by Disposal on the Land.

Reed, S.C. and T.D. Buzzell (1973) Land treatment of wastewaters for rural communities. Presented at the Rural Environmental Engineering Conference, 27-28 September, Warren, Vermont.

Land treatment of wastewater is presented as an acceptable, economical alternative. Concepts and constraints, design criteria, land requirements and cost comparisons, as well as research needs, are outlined.

1972 ENTRIES

Technical reports

Reed, S.C. (Coordinator) (1972) Wastewater management by disposal on the land. CRREL Special Report 171. (ADA 752 132).

This overview discusses disposal techniques and ecosystem responses. The nine essentially independent chapters present technical assessments of critical operational parameters and ecosystem components for land disposal

concepts. Three basic techniques of land disposal are considered in this report: spray irrigation, overland runoff and rapid infiltration.

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